

CRAIG

Machines for moving earth

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MACHINES FOR MOVING EARTH

BY

NELSON EARL CRAIG

THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

CIVIL ENGINEERING

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

PRESENTED JUNE, 1910 *ml*

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June 1, 1910

This is to certify that the thesis of NELSON
EARL CRAIG entitled Machines for Moving Earth is approved
by me as meeting this part of the requirements for the de-
gree of Bachelor of Science in Civil Engineering.

C. E. Henderson
Instructor in Charge.

Approved:

Ira O. Baker
Professor of Civil Engineering.



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I.

INTRODUCTION.

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Since the beginning of time man has been confronted with the problem of moving earth. The machines and methods used have been many and varied. Each particular piece of work requires a different machine to get the greatest efficiency in speed at a minimum cost. The different climatic conditions and the variations in the nature of the soil makes comparisons of costs almost impossible.

This discussion will cover modern earth-moving machines, beginning with the hand-shovel, the crudest one in use at the present time, and will include wheel-barrows, dump-carts, dump-wagons, scrapers, elevating graders, dump cars, steam shovels, excavators, ditching machines, and some of the devices used on the New York Barge Canal. This thesis will discuss original cost, cost and methods of operation, and adaptation to particular kinds of work for which the machines are best fitted.

In all cases where a fixed cost for moving earth is given, the average unit price of \$1.50 per day for laborers and \$1.00 per day for horses has been chosen because of the variation in price of labor from year to year. In all specific instances cited the actual cost and wages are given.

HAND-SHOVELS.

The kinds of hand-shovels used in moving earth are those with round or square points and either long or short handles. The long handled shovel is used in the removal of earth from the bottom of ditches or where the throw is great. On grade work, where the laborers stand quite close together, the short-handled shovel enables the men to move freely without interfering with their fellow-workmen. A great advantage which the short handle has over the long handle is that of the saving of the energy of the laborer. With the short handled shovel, he grasps the handle within a few inches of the load on the shovel. Thus, with a direct lift, a great amount of energy is saved every time a shovelful is raised.

In loose dry earth, the square-pointed shovel will retain more of its contents during the process of raising the load. In earth which is slightly damp, the round point is used to greater advantage, as it does not offer as great resistance in penetrating wet lumps of dirt.

The amount shovelled per day depends upon the character of the earth, the weight of the material, the way it has been loosened, the size and shape of the shovel and the proportioning of the shovellers so that they will not be kept waiting. Trantwine states that in fairly well-regulated gangs, the shovellers are not actively engaged in shovelling more than six-tenths of their time. If a man is shovelling from the face of a cut that has been undermined and broken down with picks, he can readily load eighteen cu. yds. per 10 hr. day, after the earth has been

3.

loosened. If he is shovelling plowed earth, where he must use more force in driving the shovel into the soil, he will easily load 14 cu. yds. of average earth in a day.

When wages are \$1.50 per 10 hr. day, Gillette gives the cost of loading earth with the hand-shovel as:

	Per cu. yd.
Easy Earth, light sand or loam, .	9.5 cts.
Average Earth, ...	11.0 cts.
Tough Clay, ...	13.0 cts.
Hardpan, ...	15.0 cts.
These values do not include the cost of loosening.	

The following table gives the sizes and costs of hand-shovels:



Fig. 195.
Round point cast steel shovel.
Pala de acero colado con punta redonda.



Fig. 194.
Square point cast steel shovel.
Pala de acero colado con punta cuadrada.

SIZE IN INCHES.	PRICES PER DOZEN.				REMARKS.
	1st Grade.	2nd Grade.	3rd Grade.	4th Grade.	
10 1/4 x 12 1/2	15.00	12.50	11.00	10.00	Shovels have black blades.
10 7/8 x 13 1/8	15.50	13.00	11.50	10.50	
11 3/8 x 13 1/2	16.00	13.50	12.00	11.00	
12 x 14	16.50	14.00	12.50	11.50	
12 1/8 x 14 3/4	17.00	14.50	13.00	12.00	Shovels have polished blades.
10 1/4 x 12 1/2	15.50	13.00	11.50	10.50	
10 7/8 x 13 1/8	16.00	13.50	12.00	11.00	
11 3/8 x 13 1/2	16.50	14.00	12.50	11.50	

The above prices are subject to 33 1/3 and 10 per cent discount at the factory.

WHEEL-BARROWS.

- - - : - - -

The ordinary type of wheel barrow used for earth work has a wooden or pipe frame with a shallow, round-bottomed bowl of light sheet-iron and a capacity of about 1/10 cu. yd. of earth.

In the runway is level, the full capacity of the wheel-barrow can be wheeled, but as most work of this kind involves ascending steep grades, the load is about 1/14 or 1/15 cu. yd. With wages at \$1.50 per day the cost of wheeling earth is about 5 cts. per cu. yd. per 100 ft. of haul, the haul being the distance from pit to dumps. If the runways are level and the men worked hard, the cost might be reduced to 3 cts. per cu. yd. per

Miami Dirt Barrow

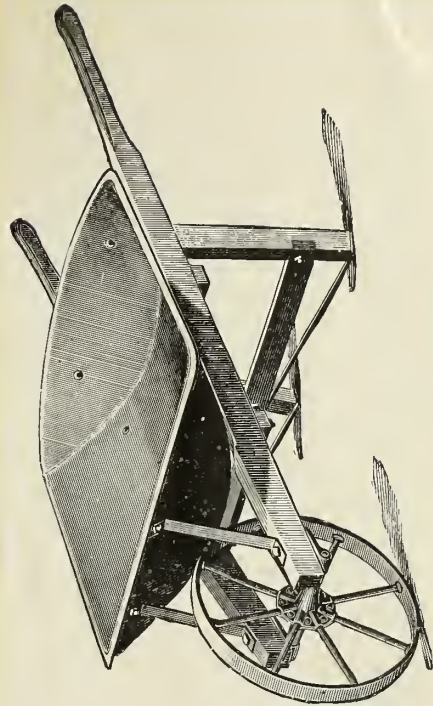
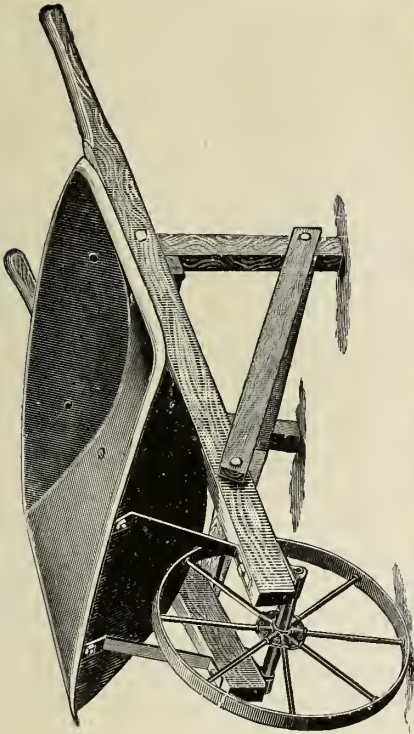
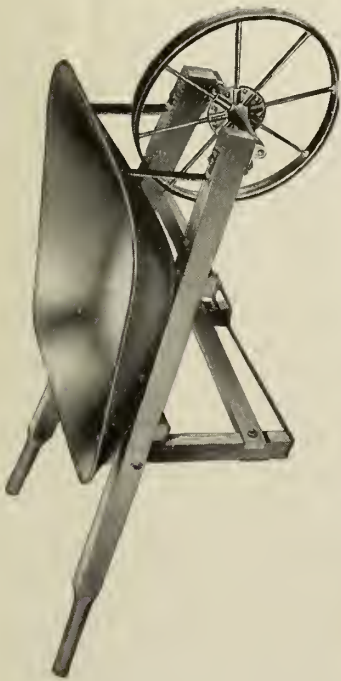


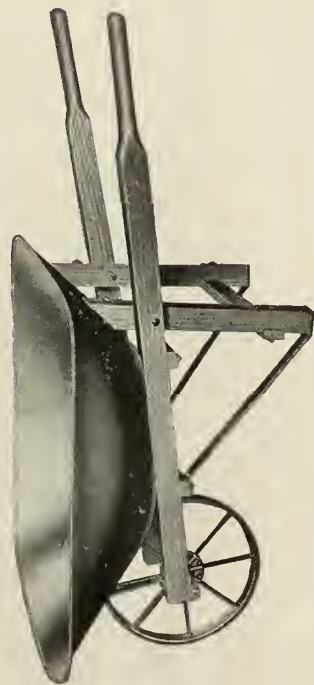
FIGURE D.



K1 AND K2 CAPACITY 3 CUBIC FEET.



C1 AND C2 CAPACITY 4 CUBIC FEET.



E1 AND E2 CAPACITY 6 CUBIC FEET.



100 ft. haul. A wheel-barrow is dumped in about $1\frac{1}{4}$ mins. which is equivalent to a loss of nearly 4 mins. per cu. yd. where 15 barrow loads make a yard; and this is equivalent to 1 ct. per cu. yd. for dumping the barrows. The time lost in changing barrows, etc., may easily add another 1 ct. per cu. yd. Thus the total cost of moving dirt with wheel-barrows is about 7 + 15 (cost of loosening and shovelling) or 22 cts. per cu. yd. per 100 ft. haul. Wheel-barrows are economical only for small jobs with short hauls (150 ft. being considered a limiting haul) and where quarters are too confined for teams.

Figure.	Capacity. Cu. ft.	Weight. Lbs.	Cost per Dozen.
D	3	55	33.60
K ₁	3	55	30.60
K ₂	3	60	32.40
Miami	3 $\frac{1}{2}$	60	32.40
C ₁	4	60	33.60
C ₂	4	65	36.00
E ₁	6	65	47.40
E ₂	6	75	50.40

These prices are not subject to discount.

ONE-HORSE CARTS.

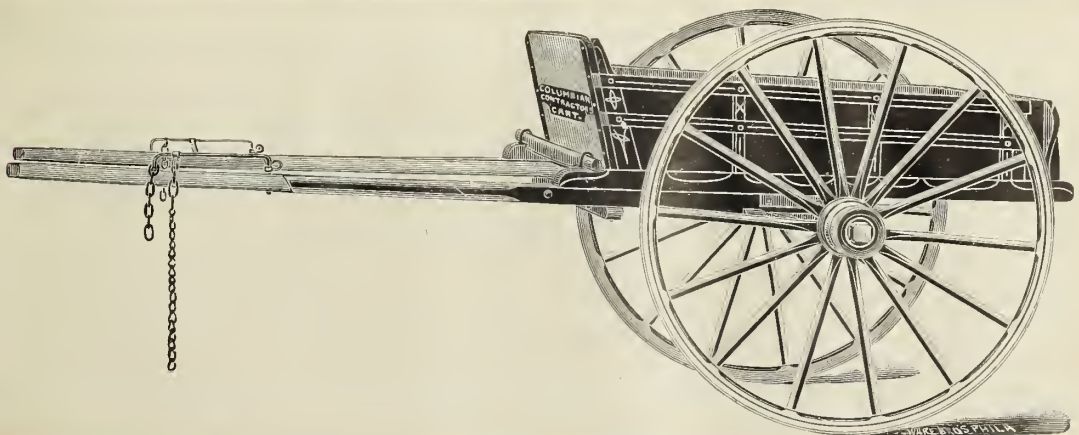
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Small two-wheeled carts drawn by one horse are often used on grade work. If the haul is level and over a hard road or a well compacted embankment, a horse will pull about 0.6 cu. yd. per load; but over poor roads or steep grades it is not safe to count on more than 0.4 cu. yd. per load. Gillette

states that on short hauls of 300 ft. or less, one driver can tend to two carts by leading one to the dump while the other is being loaded. A gang of four or five men should load a cart with 0.4 cu. yd. in 3 mins., and it takes about 1 min. to dump a cart, so that 4 mins. of cart time is lost every round trip. If the wages of a horse are \$1.00 per 10 hr. day, and the wages of the driver are \$1.50 per 10 hr. day, the wages for a cart and half a driver are \$1.75 per day. The 4 mins. lost time is therefore equivalent to 3 cts. per cu. yd. Assuming that 150 cu. yds. are delivered to the dumpman in 10 hrs., the cost is $1\frac{2}{3}$ cts. per cu. yd. for his wages. Considering that the cost of loosening and loading average earth is about 15 cts. per cu. yd. the total cost using carts is $15 + 3 + 1\frac{2}{3}$ or $19\frac{2}{3}$ cts. per cu. yd. per 100 ft. of haul. To this may be added $\frac{3}{4}$ cts. for every extra 100 ft. of haul.

DATA FOR ONE-HORSE CARTS.

Diameter :		Dimensions of box. :				Capacity :	Capacity :	Cost :
of wheels. :		Inside measure. :						
Length :		Width :		Depth :				
ft.	in.	ft.	in.	ft.	in.	lbs.	cu.ft.	
4	11	5		3	12	1,800	14	\$42.00
4	11	5	4	3	12	2,500	16	44.00
5		5	4	3	12	3,500	18	50.00
5		5	4	3	12	4,000	21	58.00



WAGONS.

- -:- -

There are three types of four-wheeled wagons commonly used on earth-work; (1) The slat bottom wagon; (2) the bottom-dump wagon; and (3) the end dump wagon. The ordinary farmer's wagon with the common box is never used on earth-work where there is a considerable amount to be moved. The cost of unloading by hand is so great that the ordinary box is excluded.

SLAT BOTTOM WAGONS are usually loaded by hand-shovels and, in some cases, by dropping the earth through traps, the material being hauled upon the platform-traps by drag, fresno, or wheel scrapers. Where the work is of sufficient size to require patent-dump wagons, they are loaded by elevating graders, steam shovels, excavators, or by dumping through traps.

Any farmer's wagon can be made into a slat-bottom wagon by removing the wagon box and replacing it with slats of 3 x 6 in. sticks for a bottom, and 2 x 12 in. or 2 x 16 in., planks for sides and ends. One man aided by the driver can dump a slat-bottom wagon holding 0.6 cu. yd. in 1 1/2 mins. at a cost of 0.4 ct. per cu. yd. for the dumpman's time and 1 ct. per cu. yd. for lost time of team, wages being \$2.00 per day for dumpman, and \$3.50 per day for the team. It takes 3 mins. for these men to dump a large slat-bottom wagon holding 1 1/2 cu. yd., when the driver removes the seat before dumping and replaces it afterwards. So that in either case the cost of dumping is about 1 1/2 cts. per cu. yd. The loss of time in loading a dumpwagon is equivalent to 2 1/2 to 3 cts., which, added to the lost team

time at the dump makes the cost for loss of time about 4 cts. where slat-bottom wagons are used.

THE BOTTOM-DUMP WAGON, or patent dump wagon, has a bottom consisting of two doors that swing downward in dumping. Three of the most serviceable and best equipped with labor-saving devices are the Watson, the Eagle, and the Austin dumpwagons. The time required to dump a drop-bottom wagon is practically nominal, and the driver dumps his own wagon, either with a foot or a hand lever. Most of these wagons are so constructed that they can be unloaded without even stopping the team. The cuts of these wagons on the following pages give an idea of the method of operation.

THE END DUMP WAGON dumps backward like a two-wheeled cart. The best makes of this type of wagon are provided with a geared device by which the dumpman slides the wagon box bodily backward over the axle of the rear wheels until it tips and dumps its load. It is not as efficient as the bottom-dump wagon as it requires considerably more time in unloading.

Wagon manufacturers also make dump-boxes to be used on the ordinary farmer's wagon. These dump-boxes are not as extensively used by large contractors as the dump-wagons. Where a contractor has a great variety of work to do the dump box is of great advantage as it can be lifted on and off the running gears in a short time. The dumping device works in almost the same manner as that on the dump-wagons.

The cost of hauling per wagon load when wages of the team and driver are \$3.50 per day and the speed of travel is 2 1/2 miles per hour while walking is as follows:

Per cu. yd. per 100 ft.

Load being 0.8 cu. yd.	0.66 cts.
" " 1.0 " "	0.53 "
" " 1.6 " "	0.33 "
" " 2.0 " "	0.26 "
" " 2.4 " "	0.22 "

In round numbers, therefore, for a load of 1 cu. yd. we must add 1/2 ct. per cu. yd. per 100 ft. haul, or 28 cts. per cu. yd. per mile haul. This does not include loading and unloading.

SLAT-BOTTOM WAGON.

Size of Tires.	Diameter of wheels.		Carrying capacity.	Capacity of body.	Cost
	Front.	Back.			
3 x 5/8"	3 ft.	4 ft. 2 in.	4,500 lbs.	1 1/2 yds.	\$85.00
3 x 3/4	3 "	4 " 2 "	6,500 "	2 "	90.00
3 x 3/4	3 "	4 " 2 "	7,500 "	2 "	100.00
3 x 7/8	3 "	4 " 2 "	10,000 "	2 1/2 "	130.00

The price of the bed alone is \$15.00

BOTTOM DUMP WAGON.

Size of Tires.	Diameter of wheels.		Distance from ground to top of body.	Capacity of body.	Cost.
	Front.	Back.			
3 x 1/2	3 ft.	4 ft. 2 in.	4 ft. 8 in.	1 1/2 yd.	\$103.00
3 x 5/8	3 "	4 " 2 "	4 " 8 "	1 1/2 "	105.00
3 x 5/8	3 "	4 " 2 "	4 " 8 "	2 "	107.00
3 x 5/8	3 "	4 " 2 "	4 " 8 "	2 "	110.00
3 x 1/2	3 "	4 " 2 "	5 " 8 "	2 1/2 "	113.00
3 x 5/8	3 "	4 " 2 "	5 " 8 "	2 1/2 "	115.00
3 x 5/8	3 "	4 " 2 "	5 " 8 "	3 "	117.00
3 x 5/8	3 "	4 " 2 "	5 " 8 "	3 "	120.00

Add for 4" tire, \$5.00

Add for steel lining, \$7.50

Add for steel lining and asbestos, \$10.00

Add for brake, \$6.50

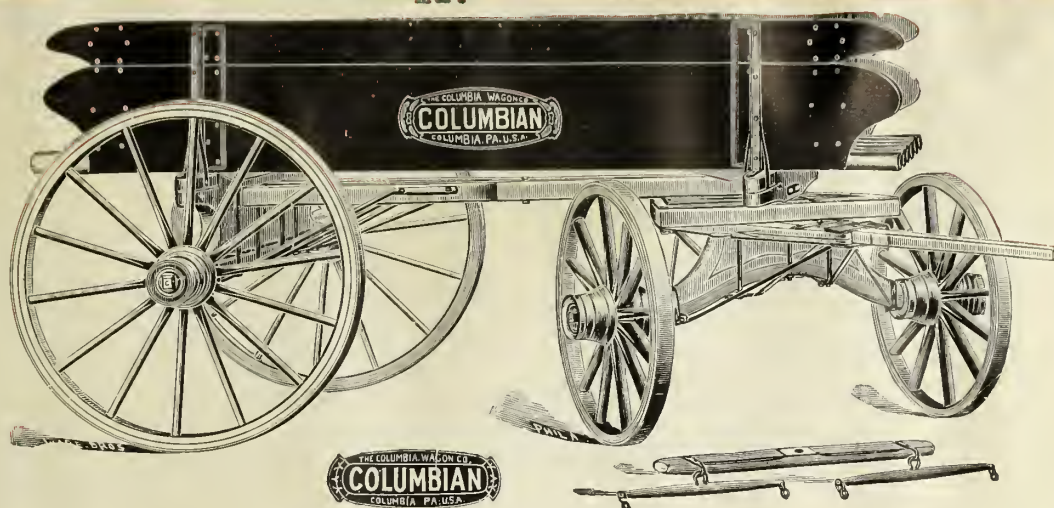
REAR END DUMP WAGON.

Dimensions of Body, Inside.				Capacity	Cost
Length	Width	Depth	Top Sides		
ft. in.	ft. in.	in.	in.	cu. yds.	
7	3-5 1/2	15	5	1 1/2	125.00
7 6	3-5 1/2	18	7	2	135.00
7 6	3-5 1/2	18	7	2	145.00
7 6	3-5 1/2	18	7	2	160.00

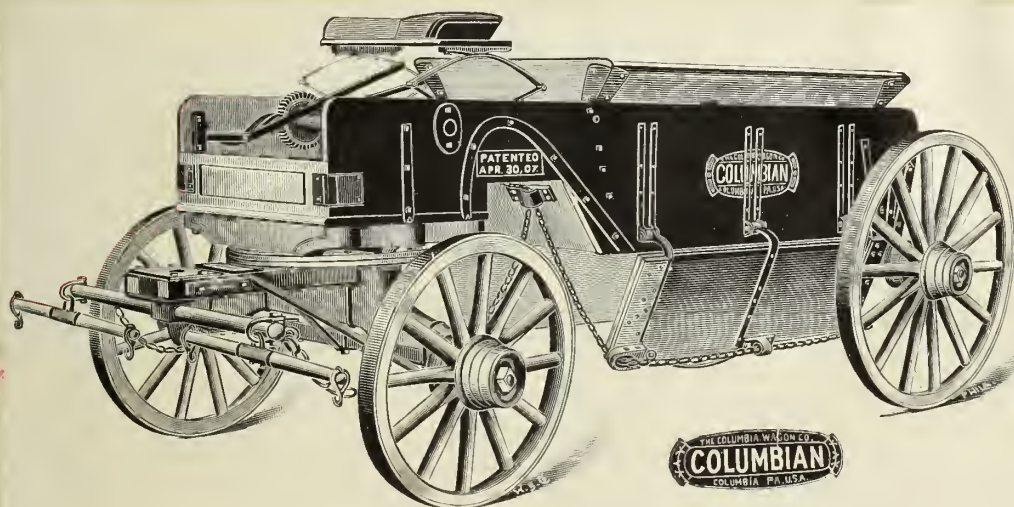
Lined with asbestos and sheet steel, extra, \$5.00

Add for brake, \$7.00

Diameter of wheels, front, 2 ft. 8 in., Back, 4 ft. 11 in.



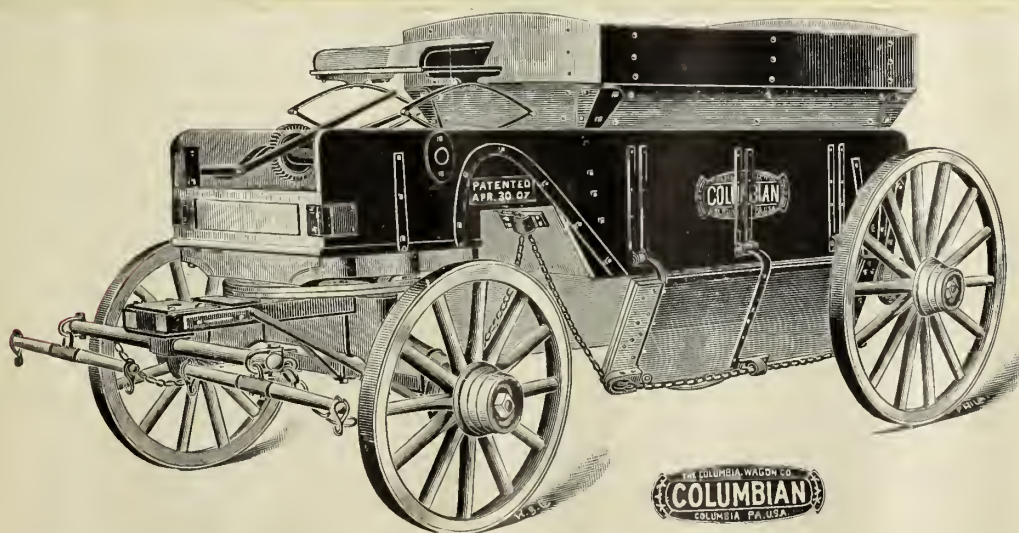
Dimensions of Our "Columbian" Contractors' Wagon



SIDE VIEW

Dimensions of Our New "Columbian" Patent Dumping Wagon

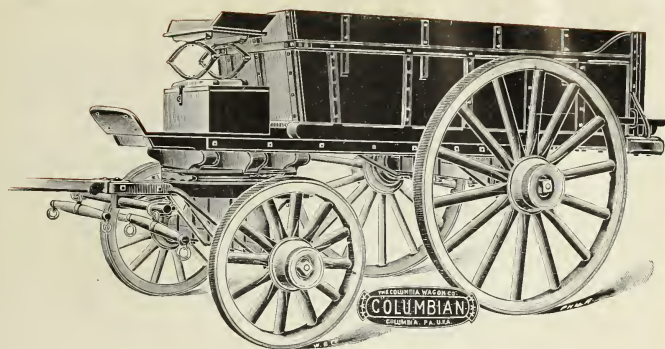
1½ and 2 yards Capacity.



SIDE VIEW

Dimensions of Our New "Columbian" Patent Dumping Wagon

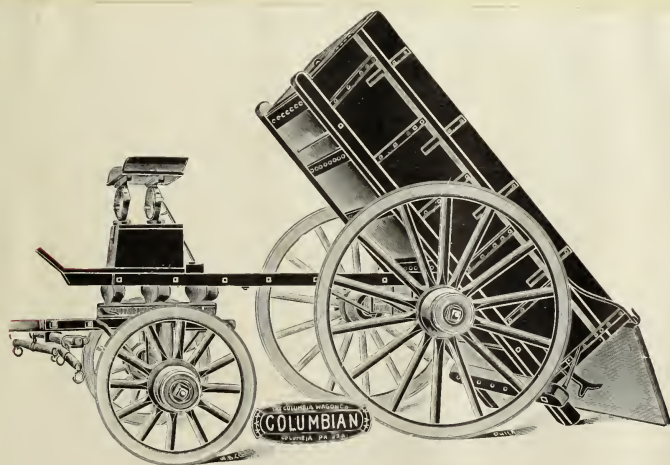
2½ and 3 yards Capacity.



Showing Wagon Ready to Load.

Dimensions of Our New Rear End "Columbian" Dumper

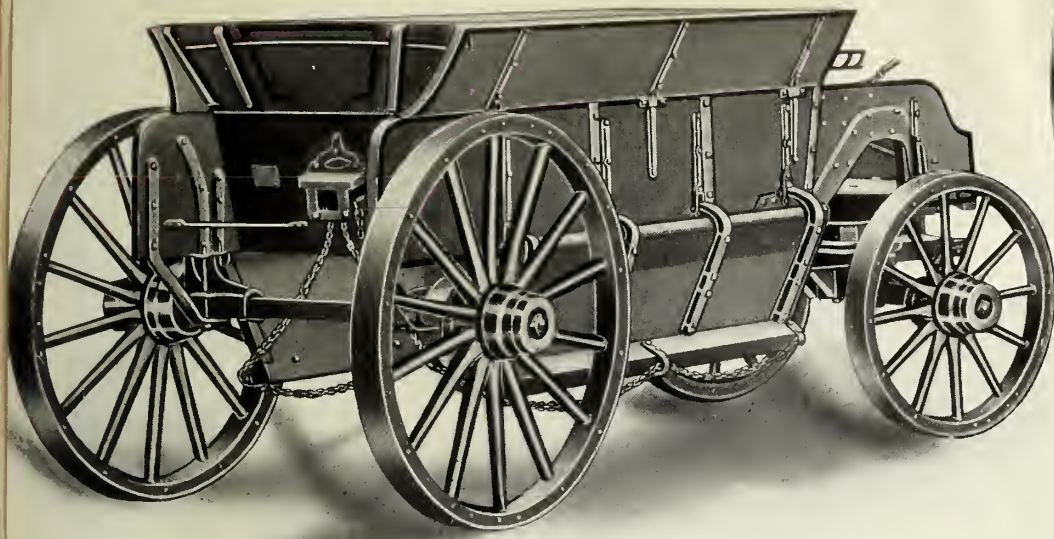
$1\frac{1}{2}$ to 2 yd. capacity.



Showing Wagon Dumped.

Dimensions of Our New Rear End "Columbian" Dumper

$1\frac{1}{2}$ to 2 yards capacity.



Rear View
of Wagon

Two-Yard Watson Dumping Wagon with Bottoms Down



SCRAPERS.

- - - - : - - - -

DRAG SCRAPERS. - A drag scraper is a steel scoop, not mounted on wheels, for scooping up and transporting earth short distances, and is drawn by a team. Drag scrapers are best adapted for burrowing at the sides of embankments and for wasting from cuts or ditches, and also for opening the mouth of large cuts; and are economical only for short distances. In working drag scrapers on short leads there are usually three teams traveling in a circle or ellipse of 150 ft. circumference. If the lead is much greater than this (say 100 ft.), a gang of at least six scrapers should be used. One man loads the scrapers in the pit as they go by, and each driver dumps his own scraper. The earth must be plowed before the scraper can be used. When the gang is working properly, the average speed of the teams is 180 ft. per min. while actually walking, and the "lost time" in unloading and dumping is $1/3$ to $1/2$ min. per trip, or about $3\frac{1}{2}$ to 4 mins. per cu. yd. for a No. 1 scraper. The man loading can readily load 1000 scrapers per day where the earth has been loosened by a plow.

It must be remembered that the "actual struck measure" capacity is the exact contents of the bowl when level full of loose earth and is about 20 per cent less than the actual struck capacity of earth when measured in place before loosening.

The following table from the book on Roads and Pavements, written by Professor I. O. Baker of the University of Illinois, gives the best approximate cost of moving earth with

a drag scraper. The haul, in the following table, is the distance from the center of the pit to the center of the dump.

Cents per Cu. Yd.

	25 ft. Haul.		25 ft. Haul.	
	Loose.	Hard	Loose	Hard
	earth.	ground.	earth.	Ground.
Loosening	1.25	2.50	1.25	2.50
Filling scraper	1.25	1.50	1.00	1.50
Hauling	5.83	6.50	7.00	7.70
Leveling	0.40	0.40	0.40	0.40
Superintendence	0.69	0.69	0.69	0.69
Wear and tear	0.25	0.38	0.33	0.50
Water boy	0.16	0.16	0.16	0.16
Total Cost	9.83	12.13	10.83	12.95

Cents per Cu. Yd.

	100 ft. Haul.		200 ft. Haul.	
	Loose	Hard	Loose	Hard
	earth.	Ground.	earth.	ground.
Loosening	1.25	2.50	1.25	2.50
Filling scraper	1.25	1.50	1.00	1.00
Hauling	8.75	0.62	10.00	11.00
Leveling	0.40	0.40	0.40	0.40
Superintendence	0.69	0.69	0.69	0.69
Wear and tear	0.42	0.63	0.53	0.80
Water boy	0.16	0.16	0.16	0.16
Total cost	12.67	15.25	14.03	16.55

The following table gives the capacities, weights, and costs of No. 1, 2, and 3 drag scrapers.

No.		Capacity.	Weight.	Cost per scraper.
1.	Without runners.	7 cu. ft.	95 lbs.	3.50
2.	" "	5 " "	84 "	3.25
3.	" "	3 1/2 "	74 "	3.10
1.	With runners.	7 cu. ft.	100 lbs.	3.65
2.	" "	5 " "	90 "	3.40
3.	" "	3 1/2 "	80 "	3.25
1.	Double Bottom	7 cu. ft.	106 lbs.	4.00
2.	" "	5 cu. ft.	96 "	3.75
3.	" "	3 1/2 "	86 "	3.60

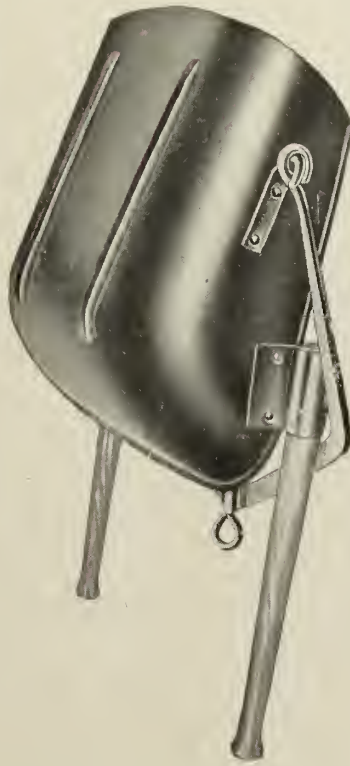
These prices are not subject to discount.

With Round Handles on Top.

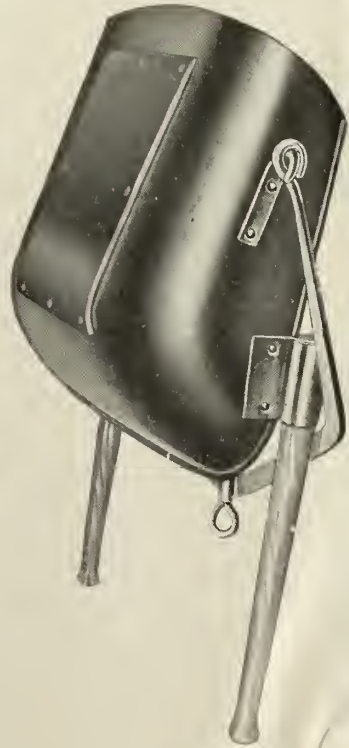
MADE WITH RUNNERS, WITHOUT RUNNERS OR WITH DOUBLE BOTTOM.



TOP VIEW OF SCRAPER WITH ROUND HANDLES ON TOP.



VIEW OF SCRAPER WITH RUNNERS AND WITH ROUND HANDLES ON TOP.



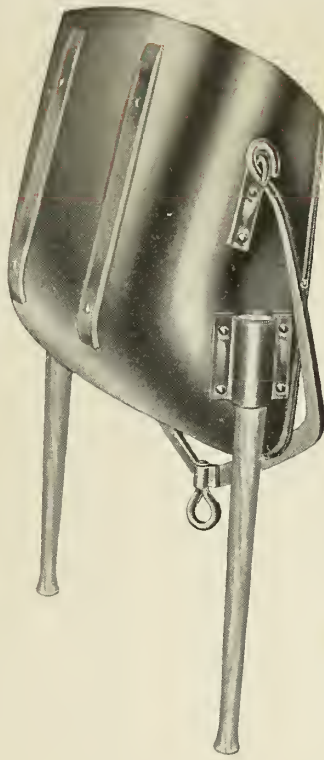
VIEW OF SCRAPER WITH DOUBLE BOTTOM AND WITH ROUND HANDLES ON TOP AND WITH ROUND HANDLES ON SIDES.

With Round Handles on Side.

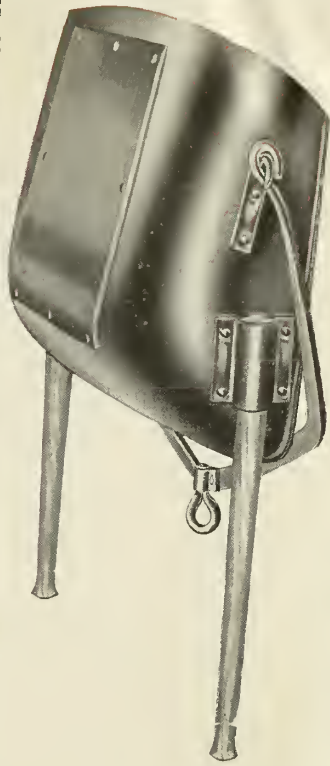
MADE WITH RUNNERS, WITHOUT RUNNERS OR WITH DOUBLE BOTTOM.



TOP VIEW OF SCRAPER WITH ROUND HANDLES ON SIDE.



VIEW OF SCRAPER WITH RUNNERS AND WITH ROUND HANDLES ON SIDE.





Haslup Solid Pressed Steel Drag Scraper

With Flat Handles on Side.

MADE WITH RUNNERS, WITHOUT RUNNERS OR WITH DOUBLE BOTTOM.



TOP VIEW OF SCRAPER WITH FLAT HANDLES ON SIDE.



VIEW OF SCRAPER WITH RUNNERS AND FLAT HANDLES ON SIDE.



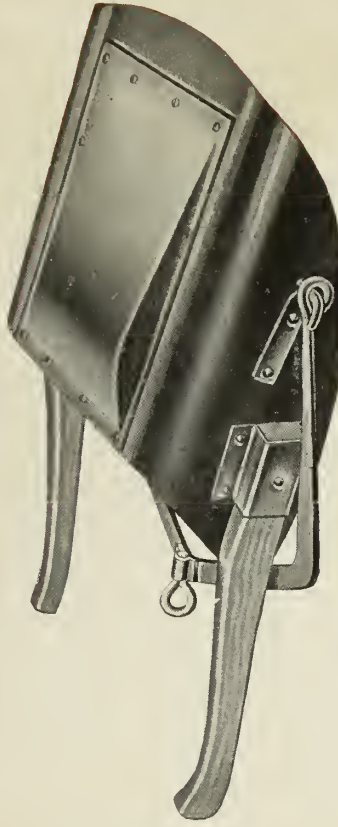
VIEW OF SCRAPER WITH DOUBLE BOTTOM AND FLAT HANDLES ON SIDE.

Haslup Square Back All Steel Drag Scraper

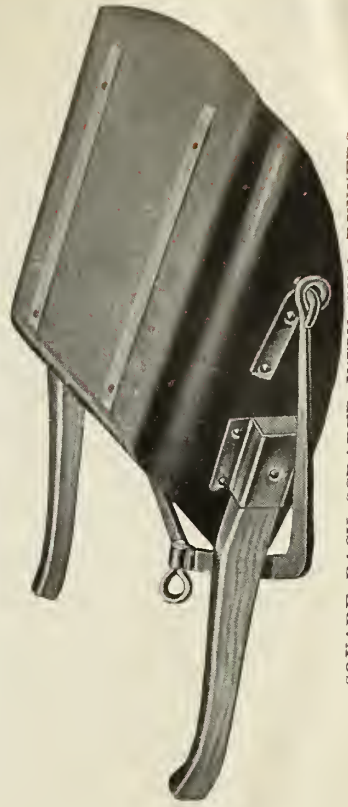
Western Pattern.



TOP VIEW OF SQUARE BACK SCRAPER.



SQUARE BACK SCRAPER WITH BROAD PRESSED SINGLE RUNNER.



SQUARE BACK SCRAPER WITH TWO RUNNERS.

WHEEL SCRAPERS. - The wheel scraper is a development of the drag scraper, being a steel scoop low hung between two wheels. As in the case of the drag scraper, the "actual struck measure" capacity is the exact contents of the bowl when level full of loose earth and is about 20 per cent less than the actual struck capacity of earth when measured in place before loosening.

Large wheelers, even in light soils, and small wheelers in tough soils, seldom leave the pit full of earth, but at the back end of the bowl there is usually a wedge-shaped unfilled space. The average load "place measure", carried by wheelers has been found to be as follows:

No. 1	1/5 cu. yd.
No. 2	1/4 cu. yd.
No. 2 1/2	1/3 cu. yd.
No. 3	4/10 cu. yd.

A snatch team, to assist in loading is generally used with a No. 2 wheeler, and always with a No. 3 wheeler. The lightest No. 1 wheelers made are to be recommended where leads are very short and rises steep, that is, wherever drag scrapers are ordinarily used, for they move earth more economically than drags. Where soil is very stony, or full of roots, drag scrapers are to be preferred, since they are more easily and quickly loaded under such conditions. With wheelers as with drag scrapers, add 50 ft. to the actual lead for turning and manoeuvring the teams, equivalent to half minute of team time each trip. Another half minute is lost in loading and dumping.

The number of wheel scrapers in a "gang" depends entirely upon the distance the earth is to be hauled. Just such number should be used as will keep a snatch team and loader busy. There should not be too many used, as in that case the teams and drivers would be obliged to wait their turn and thereby lose time. The number of gangs of scrapers that may be used on a given piece of work depends entirely upon the number of dumping places. The ground should be plowed in strips of not less than the width of the scraper bowl and while the scrapers are filling on one strip the plowman is plowing another. In this way all the teams and men are at work; no one waiting for another.

The ground should be thoroughly plowed, leaving no uncut ridges between or beneath the furrows. The scraper to be loaded is driven to the end of the plowed furrow, and the man that is to do the filling unhook the lever from the scraper bowl and elevates the lever until the hooks on the hounds catch

on the hooks on the sides of the bowl. This drops the bowl into proper position for filling. As the team is started, the filler should press the lever forward with one hand and hold one of the handles of the bowl with the other, lifting up on the handles slightly until the point of the bowl catches in the ground. The scraper will then run perfectly level and regulate the depth itself. The strain on the team can be lessened when necessary by pulling back slightly on the lever.

When the bowl is filled and while the team is in motion the lever is pulled back and down until the latch catches at the back of the bowl. The team is then turned sharply to the right or left and is driven to the dump. On arriving at the dump the man employed there for that purpose raises up the rear handles, thus depressing the point of the scraper until it catches in the ground, when the forward motion of the team will complete the dumping.

On long hauls it is advisable to have men with shovels to heap the bowl full of earth, using an automatic front end gate on the wheeler to prevent loss of material in transit.

The following table from Baker's "Roads and Pavements", gives the costs for different lengths of haul.

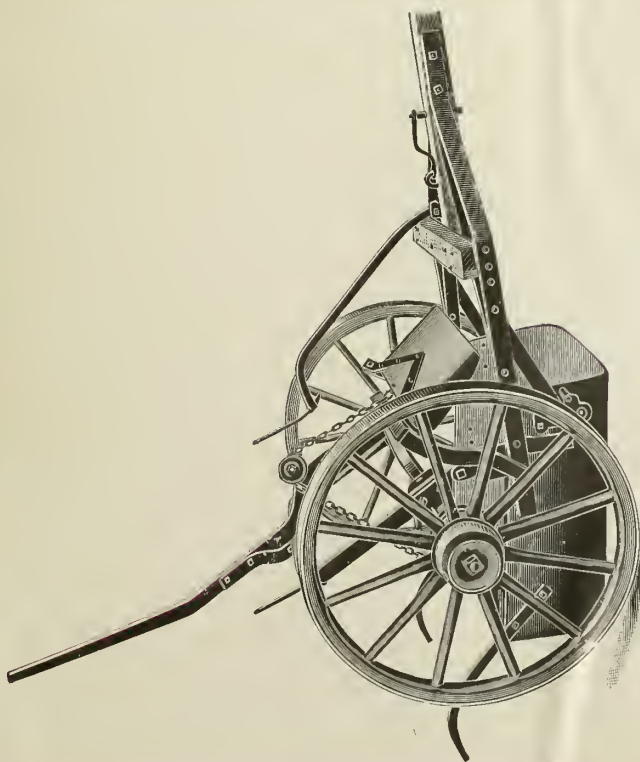
Length of haul in feet.

	Using No.1 Scraper.			Using Scraper No.3.					
	100	200	300	400	500	600	700	800	
Loosening	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Filling	1.25	1.00	1.00	1.80	1.80	1.80	1.80	1.80	1.80
scraper									
Hauling	5.83	1.00	8.00	7.77	8.77	9.77	10.77	11.77	
Leveling	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Superin-	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
tendence									
Wear and	0.41	0.58	0.75	0.53	0.64	0.75	0.86	0.97	0.97
tear									
Water boy	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
TOTAL	9.99	11.08	12.25	12.60	13.71	14.82	15.93	17.04	

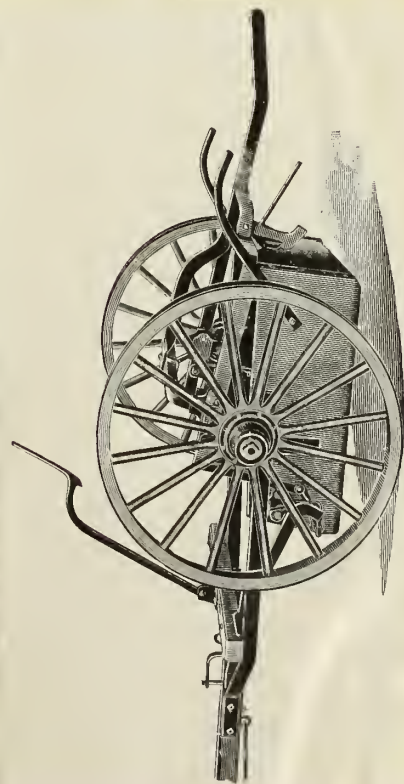
This table shows that wheel scrapers are excellent for hauling earth distances up to 700 or 800 feet.

Automatic Front End Gates

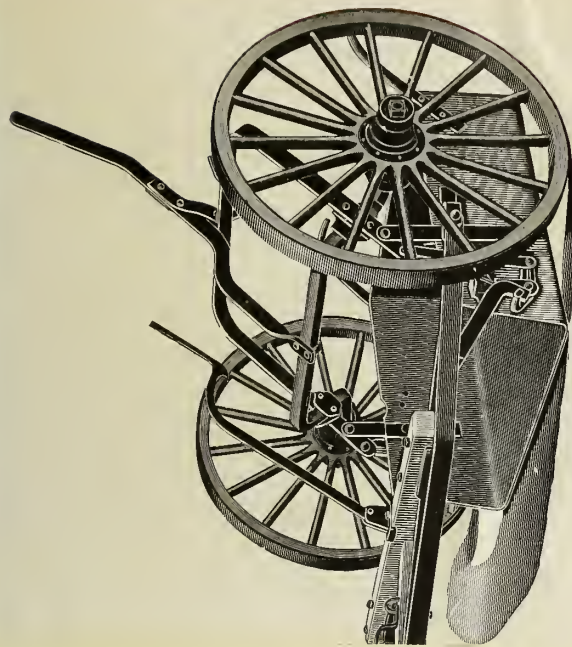
For Haslup Wheeled Scrapers



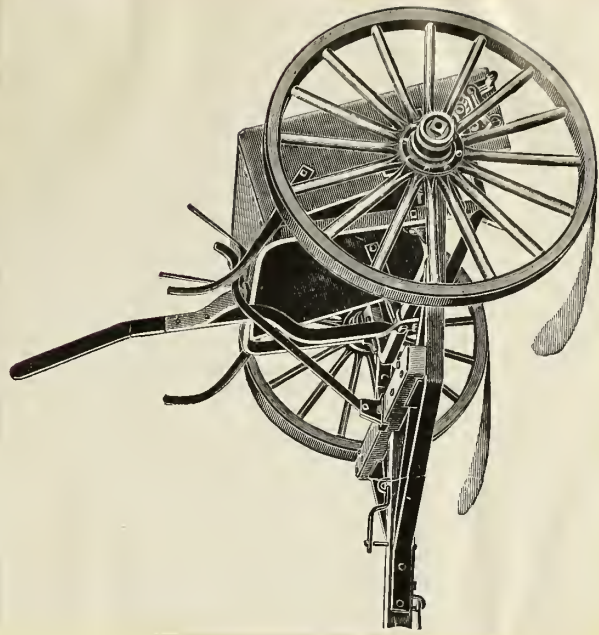
POSITION FOR FILLING



POSITION WHEN LOADED



POSITION WHILE BEING FILLED.



POSITION WHEN DUMPED.

FRESNO SCRAPER. - A fresno scraper differs from a drag scraper in being wider and having a longer cutting edge, and consists essentially of a pan, with vertical sides and back to hold the earth. To the back is attached a handle, and to the handle a piece of rope for convenience in manipulation. When loaded the scraper slides on the pan, but when empty the pan tips up and rides on runners, to save wear and tear and evade irregularities in the ground. The bar on top of the runners can be so adjusted as to make the scraper act as a leveler, dump its load in one place, or dump its load over considerable area smoothing off the top surface as the team drags the scraper forward. Two, three, four, or six horses are used, four in the majority of cases.

The scraper is useful in constructing ditches and valuable for leveling land, for irrigation and other purposes. It is adapted to taking off a thin coating of earth and depositing and spreading it in the manner needed. It is also useful in dragging earth down grade as, on account of its width, an amount of earth larger than the capacity of the scraper can be hauled in front of it. Mr. Geo. J. Specht states that with the ordinary 5 ft. fresno scraper, on a down hill haul, the loads will average 35 cu. ft. and occasionally run as high as 44 cu. ft. However, this could only occur with light, damp soil, and on a down hill pull where much material could be drifted ahead of the scraper. In almost any soil, except dry, running sand, the earth will heap up 6 or 8 in. above the top of the bowl, and will extend quite a distance beyond the front of the bowl. On level hauls or on uphill pulls it is not ordinarily safe to count on more than $1\frac{1}{2}$ cu.yd.

(measured in cut) per load, although under favorable conditions, the average load may be 25 per cent greater, while under unfavorable conditions it may be 25 per cent less.

The following table gives the sizes, weights, and costs of fresno scrapers.

Size.	Width of cut.	Weight	Cost.	(No discount).
2 Horse	3 ft.6 in.	210	11.25	In less than carload lots.
3 "	4 ft.	255	11.50	
4 "	5 ft.	275	12.00	

Engineering-Contracting gives the cost of fresno work as follows for different leads:

Lead in feet.	Cts. per cu.yd.	Cu. yds. per fresno per day.
50	5 1/2	109
100	7	86
150	8 1/2	70
200	10	60
250	11 1/2	52
300	13	46
400	16	37
500	19	31
600	22	28

The preceeding costs do not include the cost of plow-

ing, which ranges from $3/4$ to $1\ 1/2$ cts, per cu. yd., nor is the cost of foreman's wages included, which ordinarily ranges from $1/2$ to 1 ct. per cu. yd. Dressing the roadbed and slopes will usually cost an additional $1/2$ ct. per sq. yd. of surface trimmed.

The following is a record made under most favorable conditions in January, on the Truckee Supply Canal, for the Reclamation Service, near Wadsworth, Nev. Weather, clear and cold; soil dry, breaking readily, being loam, sand, and clay in irregular beds; earth moved from ditch to make the base of both banks of canal; extreme lift being about 10 ft, a small amount of earth being hauled as much as 200 ft:

Foreman, 15 days at \$4.50, ...	\$67.50
4-horse fresno and driver, 84 days at \$5.30, .	445.20
6-horse plow, driver, and holder, 13 days at 9.00, ...	117.00
Labor, clearing, helping plow holder, etc., 30 days at \$2.00, ...	60.00
Labor, loading scrapers, 32 days at \$2.00, . .	<u>64.00</u>
	\$753.70

10,219 cu. yds. moved at a cost of 7.4 cts. per cu. yd. Deducting \$38.00 as the cost of clearing, the cost per cu. yd. was 7 cts. It shows 122 cu. yds. moved per scraper per day, and had all hauls over 100 ft. been eliminated, the average would have been 130 cu. yds.

The following is a record of extremely difficult conditions. The earth was thoroughly mixed with stone, in all sizes up to 5 cu. ft. The greater part of these had to be taken to the outer edge of the embankment. The material was hard to plow and harder to load. It was all used in making banks,

mainly on one side, with little longitudinal haul.

Foreman, 16.5 days at \$3.00, ...	\$49.50
4-horse fresno, 61.5 days at \$5.30, ...	325.95
2-horse stoneboat, 11.2 days at \$3.65, ...	40.88
4-horse plow, etc., 6.5 days at \$7.40, ...	48.10
6-horse plow, 5.2 days at \$9.00, ...	46.80
Labor, loading scrapers and stoneboat, 76.2 days at \$2.00, <u>152.40</u>	
Total, ...	\$ 663.63

Estimate, 3,800 cu. yds. at 22 cts. per cu. yd. Supposing the 11.2 stoneboats to have been equal to 3 1/2 fresnos, this would give 58.5 cu. yds. per day per fresno. The cost would be almost 17 1/2 cts. per yd. This work was well directed, and showed a high yardage for the force employed, but the sidehaul accounts for the high cost.

The following is a record which illustrates the effect of haul. Weather was dry and cold, soil dry sand and silt; haul averaging 600 ft.

Foreman, 18 days at \$3.00, ...	\$ 54.00
4-horse fresno and driver, 170 days at \$5.30, ...	901.00
4-horse plow, driver and holder, 9 days at \$7.40, ...	66.60
Labor, 49 (22 loading, others finishing), at \$2.00, ...	<u>98.00</u>
Total, ...	1119.60

Estimate, 7776 cu. yds. at 14.8 cts., 28.8 cu. yds. per scraper per day.

Another contractor excavated 125 to 130 cu. yds. per day. The soil was sand and light loam. The cut generally made the banks. The ditch was narrow and ranged from 6 to 7 1/2

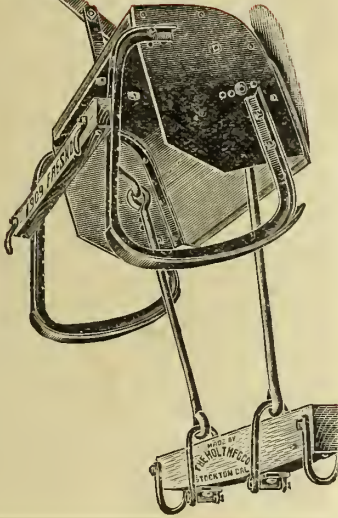
ft. deep, from bottom grade to top of banks. Scrapers worked singly, going down one bank and up the other alternately. Each driver loaded and dumped his own scraper, except one finishing scraper. The excavation cost, including practically all the finishing, for 125 cu. yds. per fresno per day, was computed as follows:

4 horses, fresno and driver, . . .	\$5.30
1-10 of 2-horse plow and driver at \$3.95.	.395
1-10 of loader, ...	.225
1-10 of formen at \$4.00,.	<u>.40</u>
	6.32

This gives 5.06 cts. per cu. yd.

It is not easy to fix the limit of economic haul with fresnos as compared with wheeled scrapers, principally because the size of the fresno load varies greatly in different soils. It is quite commonly believed west of the Rocky Mountains that for hauls beyond 200 to 250 ft. the wheeled scraper is preferable, but in tough soils or in dry sand the fresno loads may be so small that a wheeler can compete successfully on short hauls. On the other hand, in soft, damp soils that heap up and drift well in front of a fresno, the economic haul may considerably exceed 300 ft. There is no sort of haul, where the earth has been well loosened, that the fresno does not show greater economy than the drag scraper.

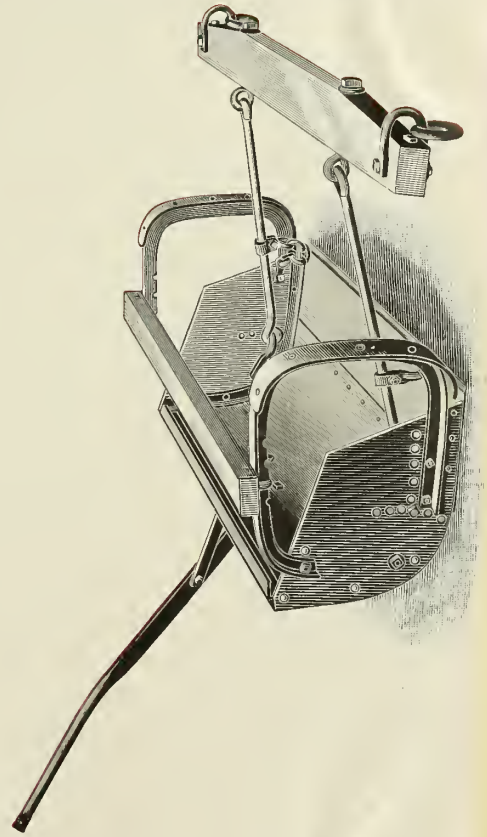
MADE IN STOCKTON



MADE IN STOCKTON



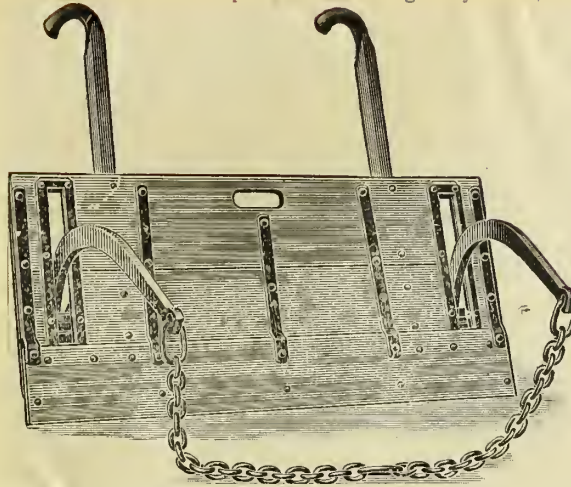
The Improved Fresno Scraper



DITCHING SCRAPER. - The chief use of the ditching scraper is that of backfilling trenches. This scraper is made of oak, shod with steel on the cutting edge. The cutting edge is 4 ft. long, which means a good wide swath cut at each forward pull. In backfilling a trench, a rope or chain about 20 ft. long is fastened to the cable chain on the scraper, and a team hitched to the end of the rope. The team works on one side of the trench, and the man holding the scraper works on the opposite side of the trench. The scraper weighs 75 lbs., and can be dragged by one man, although some contractors prefer to have two men on the scraper, especially when the bank has become somewhat compact. In a 10 hr. day a team and a driver and one man on the scraper can easily place 200 cu. yds. of back fill in a trench where no tamping is required, but even when tamping is called for, a scraper is much cheaper than a shovel for back filling. While good work can be done with a drag scraper, it is not so good a tool for backfilling as the ditching scraper for three reasons: first, the ditching scraper is lighter; second, a drag scraper is narrower; and third, a drag scraper is not so quickly dumped.

The average cost for backfilling with a ditching scraper is 2 1/2 cts. per cu. yd. while with a drag scraper 2 1/2 cts. per cu. yd. is a record.

The price of this scraper is \$3.75 f. o. b. at factory.



THE DOAN DITCHING SCRAPER
Width, 48 inches. Weight, 75 lbs.

SIDE SCRAPER. - A side scraper is especially adapted for cleaning out ditches. It is by far the most effective tool ever invented for this purpose. The scraper works cross-wise of the ditch, and is so shaped that it gets down into the bottom and cleans the ditch thoroughly. The team is hitched to the cable chain with a long rope and works back and forth on the bank. The body of the scraper is made from a single piece of steel, $\frac{3}{16}$ in. thick, with steel angles. The handles are factened to the sides with steel sockets, the outer ends being connected by a steel rod.

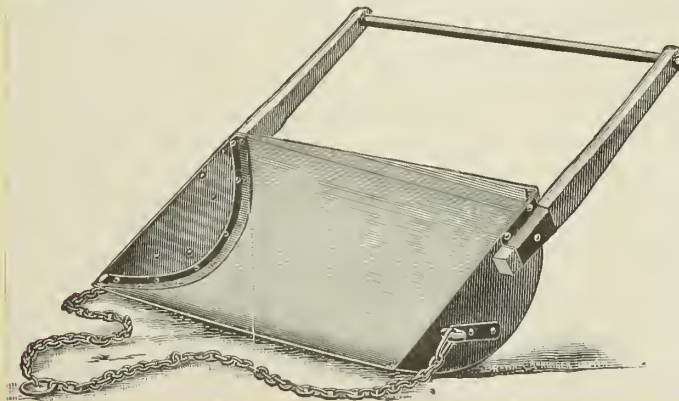
The following table gives descriptions of the side scraper.

No.	Width. in.	Weight. lbs.	Cost.
1	36	100	5.50
2	42	110	5.75

No discount.

HASLUP SIDE SCRAPER

For Cutting and Cleaning Open Ditches or Canals



ELEVATING GRADER.

- - - : - - - -

An elevating grader consists essentially of a four-wheeled truck provided with a plow which casts its furrow upon an endless belt which elevates the material and deposits it in wagons as fast as they are driven under the belt. For loading wagons the carrier is arranged at about nineteen feet, which allows ample elevation and is convenient for turning. The wagons are driven so the earth from the carrier falls into the wagon, both driving at low speed until the wagon is loaded; the machine slows down while the loaded wagon drives out and another takes its place. The machine is adapted to loading wagons on road work, but is especially suitable for reservoir, irrigating ditches, and canal work where there is a prairie soil. For successful operation, the soil must be free from boulders or roots. The machine will work on stone and gravel roads and stiff clay, but in light sand it refuses to elevate as the plow will not turn a furrow. There must be considerable room in which to turn the machine and manoeuvre the teams going and coming. It is most advantageous to use the machine on stretches of a mile in length, so that the time lost in turning and manoeuvring the machine is reduced to a minimum. In digging ditches or canals, the earth should be removed in layers, that is to say, the entire width should be taken off first, gradually reducing the number of parallel furrows, so as to dig a properly shaped ditch or canal.

The Good Roads Machine Company, of Fort Wayne, Indiana, guarantee their machine to have an output per ten hour day of 1000 cu.yds. in a tough clay soil; and numerous testimonials show that

1,400 to 1,600 cu. yds. is not unusual where the soil is suitable and there is a sufficient number of teams to take the material away from the machine. In most cases, however, it is best to assume the output as 500 to 600 cu. yds., on account of repairing the grader, waiting for teams, etc.

Manufacturers claim that a grader will fill a wagon holding from 1 1/2 to 2 cu. yds. as quickly as a wheel scraper can be loaded holding one third to one fourth as much. The time of loading is about 15 or 20 secs. with a loss of 15 secs. while the loaded wagon is driving out and the empty one coming in.

A grader costs about \$1,000.00, and is hauled either by a 25 H.P. traction engine or by 12 horses. It requires 2 men to operate the grader, and where horses are used, 2 men to drive the horses. Where a traction engine is used, 2 men operate the grader, 1 man operates the traction engine, and one team is kept busy part of the time hauling coal and water for the engine. The engine burns about 1500 lbs. of coal per 10 hrs. and uses about 6 tons of water to furnish steam. The grader travels about 150 ft. per min. when hauled by an engine, and it takes 1 1/2 mins. to turn around at each end of its run, describing a circle of about 50 ft. diameter in turning. All streets of 36 feet or upward in width can be handled without difficulty, but streets under this width cause some rehandling.

Gillette says that a team hauling earth from a grader must perform a large percentage of waste labor following the grader, and this is equivalent to adding about 400 ft. to the lead. If 3 horses and a driver are worth \$4.50 a day, and the load is

1 1/4 cu. yds., the cost of hauling is 0.6 cts. per cu. yd. per 100 ft. of haul; so that the waste distance traveled (400 ft. lead) adds 3 cts. per cu. yd. to the cost. With wages of single horses at \$1.00 and men at \$1.50, the cost is as follows, with an output of 500 cu. yds. per 10 hours.

	Per cu. yd.
(1) Lost team time (400 ft. added to lead). . . .	2.5 cts.
(2) 12 horses on grader and 4 men, ...	4.0 "
(3) 5 men on dump spreading, ...	1.5 "
(4) Plant rental, ...	<u>1.5</u> "
Total, ...	9.5 cts.

By using a leveling scraper the third item can be reduced. Comparing traction engine outfit with the outfit using horses we have:

	Per day.
3/4 ton coal at \$3.00, ...	\$2.25
1 engineman, ...	3.00
2 grader operators, ...	5.00
1 driver and team hauling coal and water, ...	3.50
Rental of engine, ...	<u>5.00</u>
Total, 500 cu. yds. at 3.75 cts.	18.75

This about 1/4 ct. cheaper than the former case.

On the Chicago Drainage Canal, a grader required 15 1 1/2 yd. wagons to remove the earth when it was kept in constant motion. The lead was about 1/2 mile. The machine used required 5 men to operate it and three men to help load the wagons. The

total number of men including the 15 teamsters was 23. The capacity while working was about 75 cu. yds. per hour. With three-horse wagons the average 10 hr. day's output was 500 cu. yds. of top soil.

In grading the streets of Conandaigua, N.Y., a traction engine was used to haul the grader. The streets were 60 to 75 ft. wide between property lines and 36 ft. between curbs, and there was no trouble in turning the engine and grader between walk lines. Fifty wagon loads, of $1\frac{1}{2}$ cu. yds. each were readily loaded per hour.

On road work in Oklahoma, under very favorable conditions, the cost of loading wagons with a grader was 2.1 cts. per cu. yd. Twelve horses and 4 men were used on this machine.

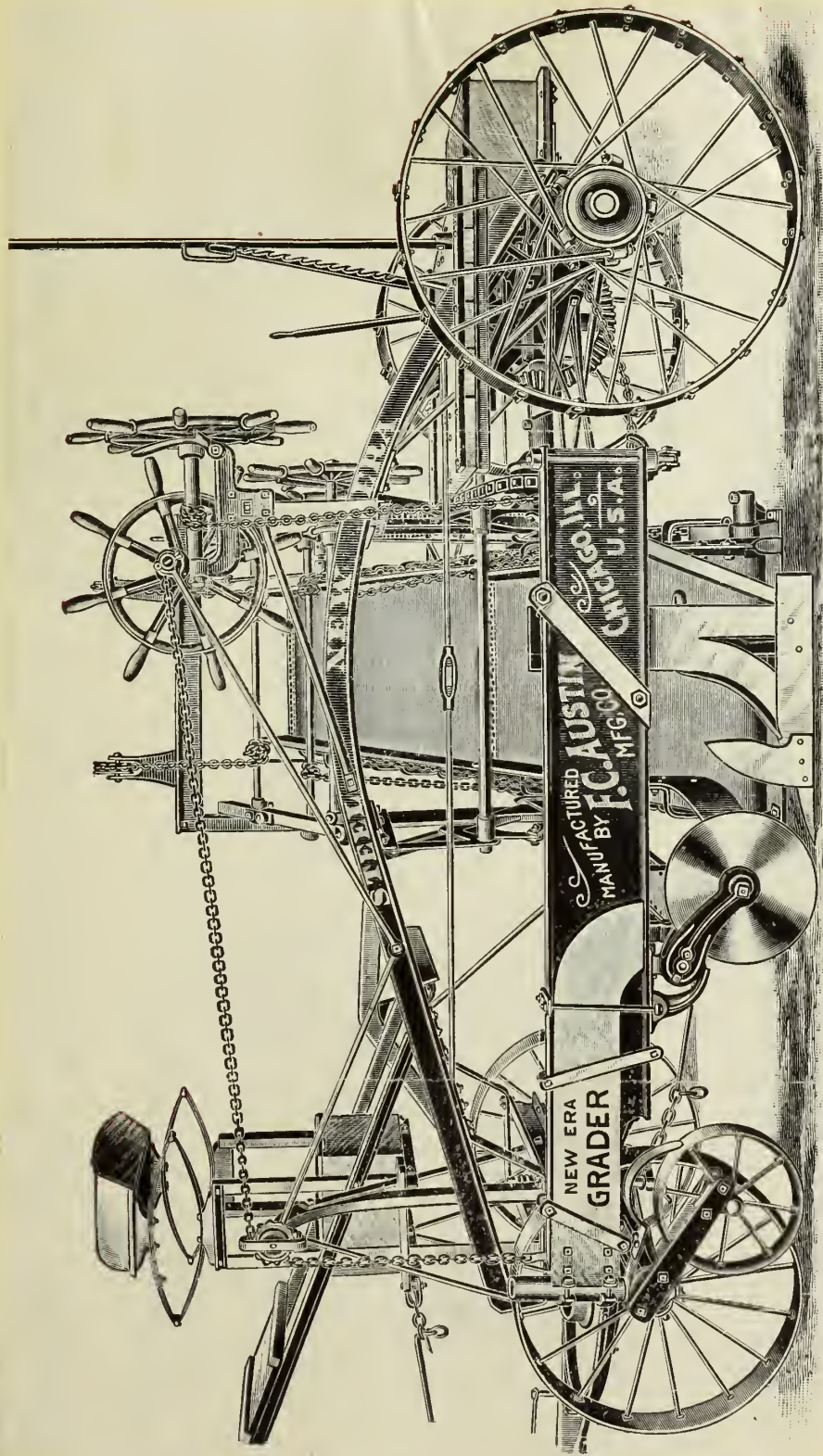
Table showing number of wagons required to serve a grader at different lengths of haul, with estimated cost per cu. yd.

Length of haul.	No. of Wagons.	Total daily cost.	Cost per Cu. Yd.
ft.			cts.
140-300	5	34.75	3 $\frac{1}{2}$
410	6	38.25	3 $\frac{7}{8}$
500	7	41.75	4 $\frac{1}{5}$
590	8	45.25	4 $\frac{1}{2}$
680	9	48.75	4 $\frac{7}{8}$
950	12	60.25	6
1220	15	70.75	7
1670	20	88.25	9
1940	23	98.75	10
2300	27	112.75	11 $\frac{1}{4}$
2600	30	122.25	12 $\frac{1}{4}$
3000	35	157.25	15 $\frac{1}{10}$

In the construction of canals for irrigation and drainage the grader is used to great advantage. It can excavate canals from thirty to thirty-five feet wide on top and four feet deep, and deliver the earth on the embankment direct. For deeper and wider ditches it must be used as a wagon loader, and the earth hauled in wagons. Under favorable conditions a grader will build one mile of ditch, of the following dimensions, in the time and cost given in the table.

Top Width.	Bottom Width.	Depth.	No. hours per mile.	Cost per mile.
ft.	ft.	ft.		
24	16	4	150	275.00
20	12	3 1/2	110	200.00
16	10	2 1/2	60	110.00
12	8	2	40	70.00
6	2	1 1/2	10	18.00

The working force on the preceeding work was six teams, two drivers, and one operator.



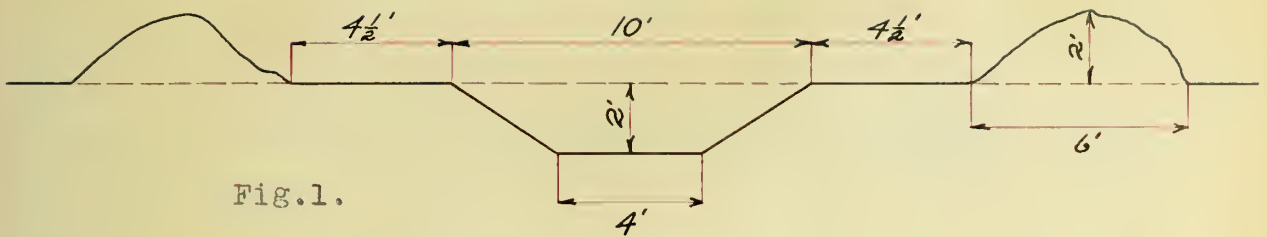


Fig.1.

Figure 1 shows a ditch 10 feet in width at the top and finished 4 feet wide at the bottom and depth 2 ft. The banks have a pitch of $1\frac{1}{2}$ to 1 with berme $4\frac{1}{2}$ feet in width at each side. The embankment is six feet at the base and 2 feet high. The construction of this ditch would require the handling of approximately 2,750 yards of material per mile, and under ordinary favorable conditions could be finished in two days time. In cutting a ditch of this size use an elevator 16 feet in length, throwing the dirt from the left side of the ditch to the right bank and vice versa. This method of handling dirt is generally termed crossfiring.

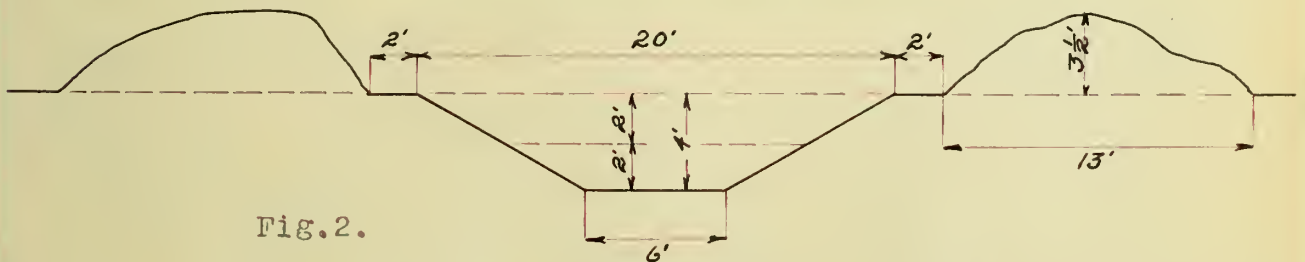


Fig.2.

Figure 2 represents a ditch 20 feet wide at the top, 6 feet at the bottom and 4 feet deep. The banks, however, have a pitch of $1\frac{3}{4}$ to 1 with a berme 2 feet wide at each side. The embankments are 13 feet wide at the base and $3\frac{1}{2}$ ft. in height. For completing a mile of this ditch a trifle over 10,000 yards of earth must be handled, which under ordinary conditions would re-

quire about ten day's time with the machine. This ditch can be made by taking out the first 2 feet with a 16-foot elevator, and working from the outside to the center, then using a 19-foot carrier for taking out the last 2 feet in depth, crossfiring as above stated.

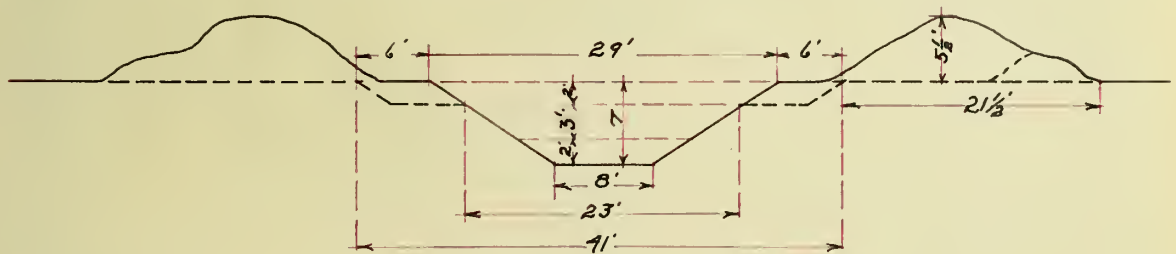
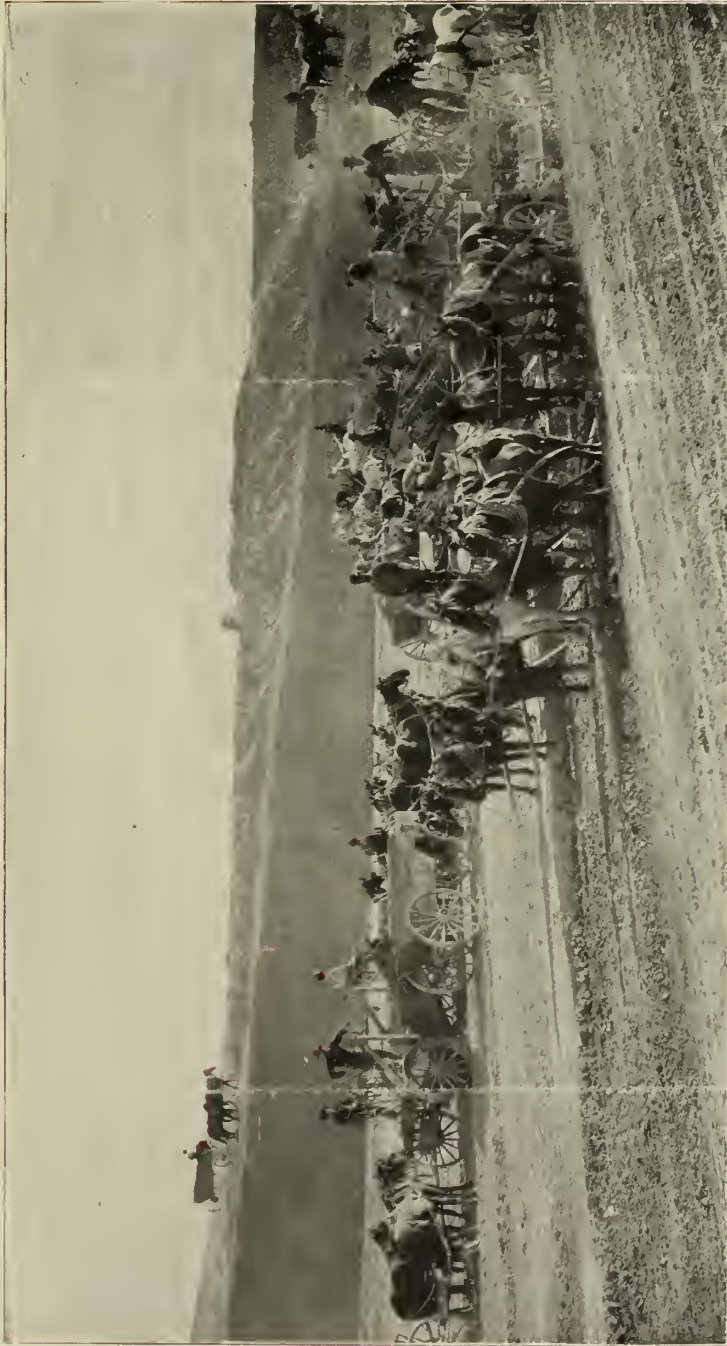


Fig. 3.

Figure 3 illustrates a ditch 29 feet wide at the top and 8 feet wide at the bottom, 7 feet in depth. The banks have a pitch of $1\frac{1}{2}$ to 1 with a berme 6 feet wide on each side. The embankments are $21\frac{1}{2}$ feet wide at the base and approximately $5\frac{1}{2}$ feet high. To construct a canal of this size would require the handling of about 25,000 cu. yds. of earth per mile. This being a deeper ditch than can be made directly with an elevating grader, it is necessary to take out the first two feet in depth (as shown in dotted lines) using a 22-foot elevator on bank. After this two feet is removed the ditch will be narrowed down to practically 23 feet. The following three feet can be taken out by working from the outside to the center, delivering all the earth on the banks as stated above. The remaining two-foot section can then be taken out by cross-firing, working from the center to the outside and in this manner deliver the earth on the opposite shoulder, which will fill in the extra two feet surplus

cutting of the top section, and in this manner the berme filled out and the ditch completed as shown in diagram.





Kilpatrick Brothers & Collins Rebuilding the Union Pacific Railroad Across the State of Wyoming.

DUMP CARS.

- - : - -

Small steel cars of various sizes and styles are being used more and more extensively in earth excavation. Wooden cars have been used for this purpose many years, but during the past decade the all steel car has come into use and is growing in favor with contractors.

Steel cars are made with either a square or V-shaped box; and dump double side; end; or all around. Round channel steel frames are the most desirable form for a car up to 2 cu. yds. capacity for light locomotive traction, horse, or hand power. Square channel or I-beam frames are the best construction for cars with a capacity from 2 cu. yds. and larger. An important feature with regard to the satisfactory operation of a car is the locking device used when dumping. A good locking device prevents accidental discharge of contents and consequent injury of workmen. Special automatic locking devices have been designed so that a car can be dumped only by releasing the lever opposite to the side that it dumps. In this way a car can never dump to the side from which it is operated. When the body of the car returns from the dump to its load-carrying position, it is locked automatically. Dump cars are made with brakes of either the screw or lever type.

Steel dump cars of the cradle type are made as double side, end, or all round dump cars. They are made entirely of steel, with a channel steel main frame forming a round buffer at each end, which gives the car as great resistance and protects it in case of accident. They have cast steel wheels and the body is made very strongly. The supporting cradles are made of channel

steel and are rivetted to the frame. These cars are arranged in such a way that the box can be put in a slanting position while being dumped, thereby lowering the loading height. The cars are provided with a brake angle between the wheels, so that even if they have no brake they can be braked by means of a stick or pole put between the brake angles and pressing on the wheels.

The following table gives the general dimensions, weight, and cost of the cradle dumping car.

Similar to Figure.	Capac- ity. Cu.Ft.	Gauge of track. In.	Overall Dimensions.			Weight Lbs.	Price
			Length. Ft.In.	Width. Ft.In.	Height. Ft.In.		
151	18	20	5 7	4 3	3 4	700	78.75
151	27	20	5 11	4 10	3 11	850	87.00
151	18	21 1/2	5 7	5 3	3 4	700	84.00
151	18	24	5 7	4 3	3 8	750	82.50
151	27	24	6 2	4 10	4 0	875	87.00
151	36	24	6 9	4 11	4 3	975	102.00
151	36	30	6 9	4 11	4 5	1050	105.00

These prices are net and not subject to discount.

This type of car is built for capacities of from two-thirds to one and one-half yards. Fig. 1760 shows a car in up-right position. Fig. 7661 shows a car in a slanting position to facilitate loading. Fig. 7662 shows same car in a dumped position.

Fig. 1143 shows a car with a screw brake and brakeman platform. Bodies with crane attachment and supporting bracket, Figure 7663, are used when they are to be lowered into an excavation for loading, and the unloading process takes place when they rest on the frame.

Bodies with crane attachment, Fig. 7664, are used when the loading is performed, while the body rests on the frame of the car, and the unloading takes place while the body is supported by the crane. Fig. 1765 shows an automatic locking device.

Fig. 7665 shows another type of locking device which allows the cars to rest in a semi-tipped position, thus facilitating loading. However, this service does not work automatically.

Fig. 7666 shows all steel bumper plates and coupling device, which are applied to the round channel frame cars.

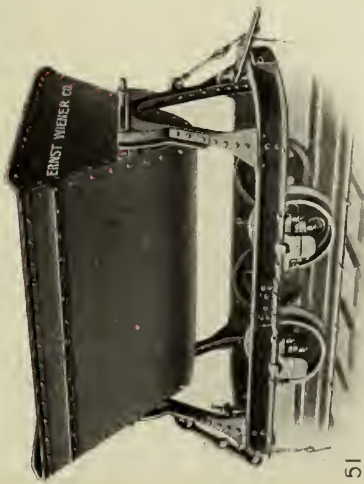


Fig. 151.
Standard double side all steel dump car.
Carro normal de volteo por los lados, de acero.

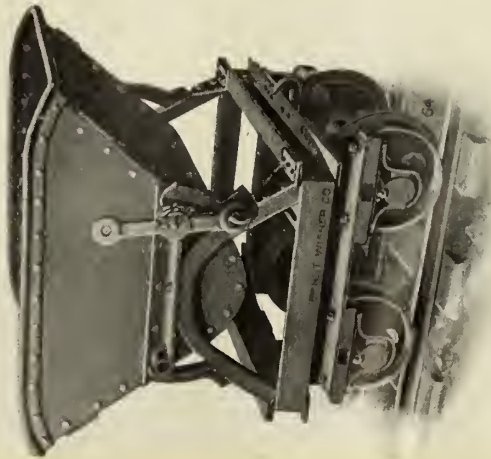


Fig. 64.
Same as fig. 151 but dumping to both ends.



Fig. 66.
Crane attachment to be used together with
car fig. 65.
Suspensor de grua, que se usa con nuestro
carro fig. 65.

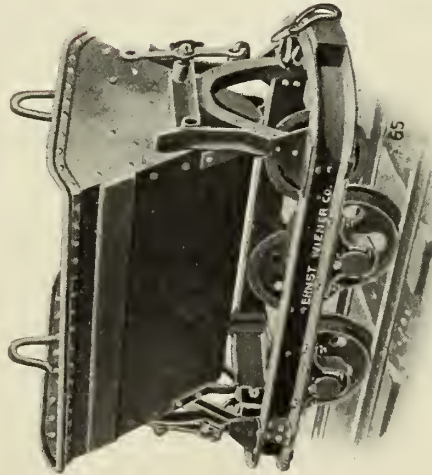


Fig. 65.
Standard dump car with crane attachment.

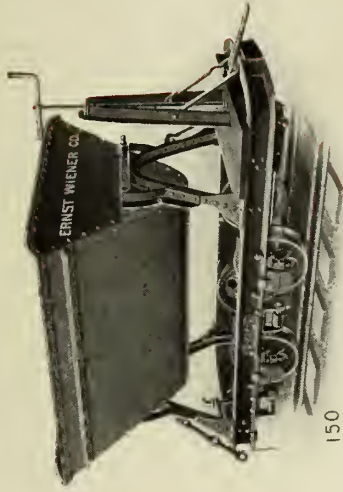


Fig. 150.
Same as fig. 151, but with a strong brake and
platform for the brakeman.
Igual á la fig. 151, pero con retranca fuerte y
plataforma para el retranquero.

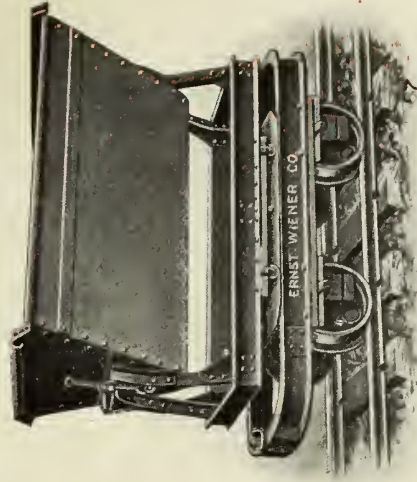


Fig. 67.
Same as fig. 151, but dumping all around.



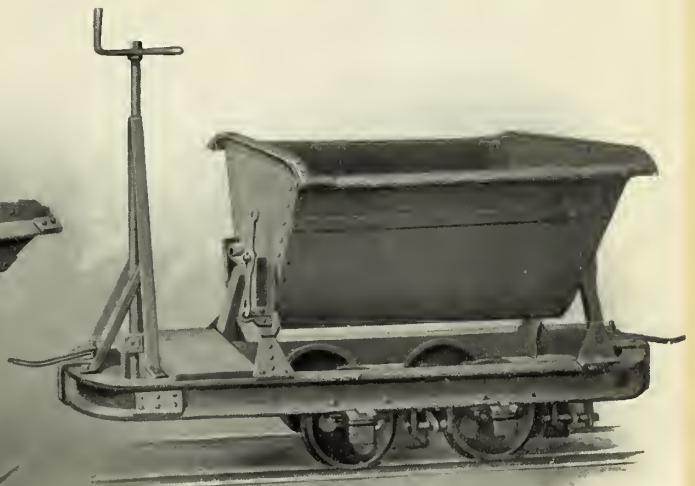
7661



7662



1760



1143

Steel dump cars of the rocker type are made double side or end dump. They have a similar construction to the cradle type and have all the advantages of loading and unloading.

The following table gives the dimensions, weight and cost of the rocker type of dump car.

Similar to Figure.	Capac- ity. Cu.ft.	Gauge of Track.	Overall Dimensions.			Weight Lbs.	Price
			Length.	Width	Height.		
173	18	24	6'-9"	4'-0"	3'-8"	900	81.00
173	27	24	7'-4"	4'-2"	3'-11"	950	86.25
173	40	24	8'-1"	4'-11"	4'-5"	1325	105.00
173	27	30	8'-8"	4'-2"	3'-11"	1000	90.00
173	40	30	8'-1"	4'-11"	4'-1"	1425	116.25
164/5	54	30	8'-8"	5'-3"	4'-10"	1675	135.00
173	40	36	8'-1"	4'-11"	4'-8"	1500	120.00
164/5	54	36	8'-8"	5'-3"	4'-11"	1770	138.75

Cars are provided with brake working on all 4 wheels and a platform for the brakeman for \$30.00 per car.

Standard "V".

Double Side Dump Cars, Rocker Type.

Yards Capacity.	Gauge.	Over-all Length.	Width.	Height.	Wheel.
1	24"	6'-2 1/2"	4'-10 3/4"	4'-0"	12"
1 1/2	24"	7'-3 5/8"	5'-7"	4'-4"	14"
1 1/2	36"	7'-3 5/8"	5'-7"	4'-5"	16"
2	36"	7'-5 1/4"	6'-6"	4'-8"	16"

Cars are equipped with roller bearings and round bumper.

Yards Capacity.	Gauge.	Over-all length.	Width.	Height.	Wheel.
2	36 "	7'-10 7/8"	6'-7"	4'-8"	16 "

Cars are equipped with roller bearings and spring bumper.

Yards Capacity.	Gauge.	Over-all length.	Width.	Height.	Wheel.
2	36 "	7'-10 7/8"	6'-7"	5'-1"	16 "
3	36 "	8'-7 1/4"	7'-4 1/2"	5'-6"	18 "
4	36 "	10'-9"	7'-4 3/4"	5'-9 1/8"	20 "
6	4'8 1/2"	11'-5"	8'-5"	7'-0"	24 "

Cars are equipped with elliptical spring bearings and spring bumper.

Yards Capacity.	Gauge.	Over-all length.	Width.	Height.	Wheel.
4	4'8 1/2"	11'-4"	8'-4"	7'-3"	30 "
12 ¹	4'8 1/2"	25'-3"	8'-9"	7'-4"	33 "

Cars are equipped with elliptical spring bearings and M.C.B. Coupler.

¹Three moulds and arch bar trucks.

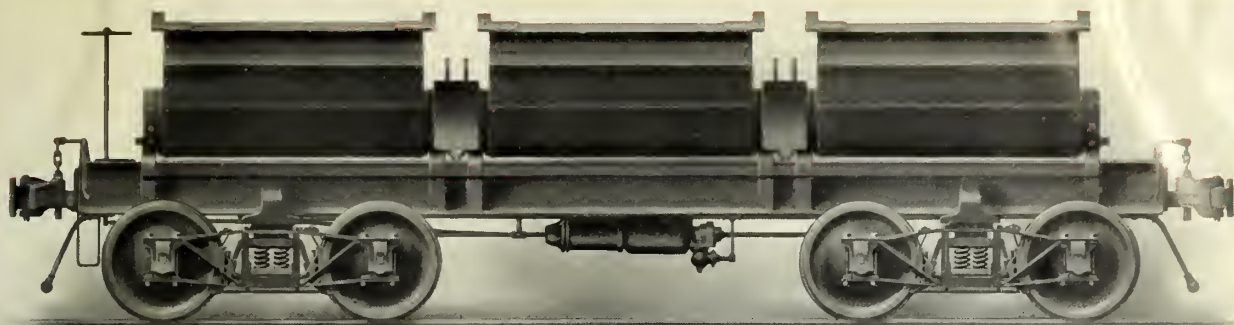
Fig. 5577 (a), page 52, shows a rocker dump car with a round bumper in loading position for eighteen cu. ft. up to 1 1/2 yds. capacity.

Fig. 5577 shows same car in dumped position.

Fig. 5578 shows a car with square frame and spring bumper for 2 yds. capacity.

Fig. 5590 shows a car with square frame and spring bumper for capacities from 3 to 6 yds.

Fig. 5576 illustrated a double side "V" dump car mounted on double trucks and having three V-shaped bodies. The car is generally built for a standard gauge and with a capacity of 12 to 18 cu. yds., each body having a capacity of 4 to 6 cu. yds. The bodies operate individually, having no connection or relation to each other. This construction also has an advantage in the event of the car becoming damaged, inasmuch as a body that is damaged and rendered inoperative does not interfere with the operation of the other two-thirds of the car. The damaged body can be removed and another body substituted. These cars can be equipped with hand and air brakes, M.C.B. automatic couplers and spring draft gears.



5576



5577A



5577



5590



5578

Square Box Side Dump Cars are built for capacities from 1 1/2 to 12 cu. yd. They are designed to dump clear of the track and the dumping method is exceedingly simple and thoroughly reliable. These cars are built to any gauge. If the service is such that the use of no special type of dump car is imperative, square box dump cars are recommended on account of the wide field of usefulness in which they may be employed. While the first cost is more expensive than the V-shaped car, yet the varied fields into which they enter, as compared with the limited use of other cars, reduce the first cost and make them very economical. However, they are not so extensively used as the V-shaped cars.

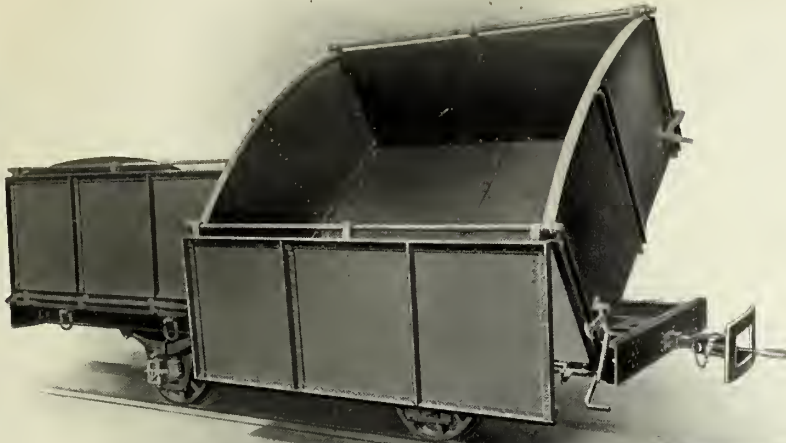
Fig. 7671 illustrates two bodies on one frame, which dump to either side independently. The bodies are dumped by means of a crane. Therefore the unloading operation always has to occur at the same place.

Fig. 7672 illustrates a single body car which may be dumped to one side only. The car is provided with round channel frame and is designed for capacities up to 2 cu. yds.

Fig. 7673 is a car built in capacities up to 8 cu. yds., which may be dumped to both sides. This car can be so arranged that when dumped the door opens automatically.

Fig. 7674 shows the same car in dumped position.

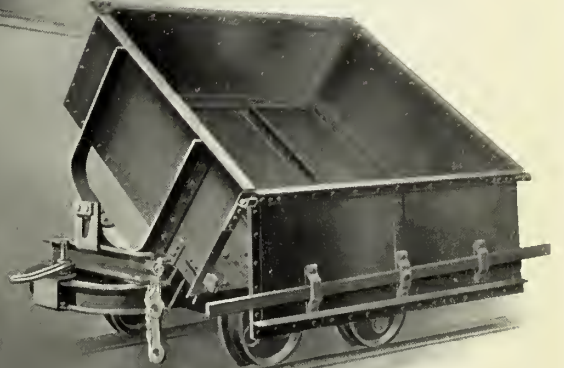
Fig. 7675 shows a slightly different type of car which may be dumped to either side. This car is very low and has proved to be especially useful for contractor work in tunnels.



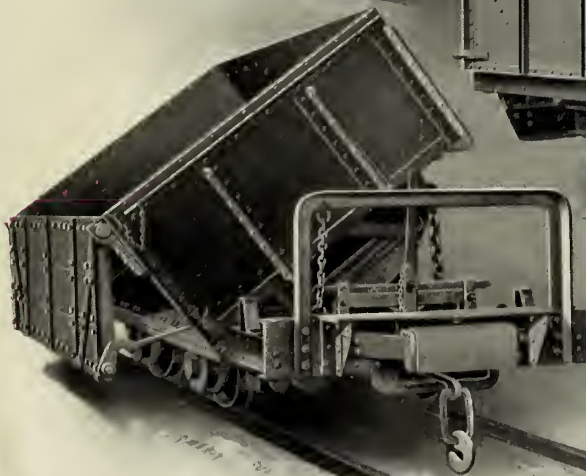
7671



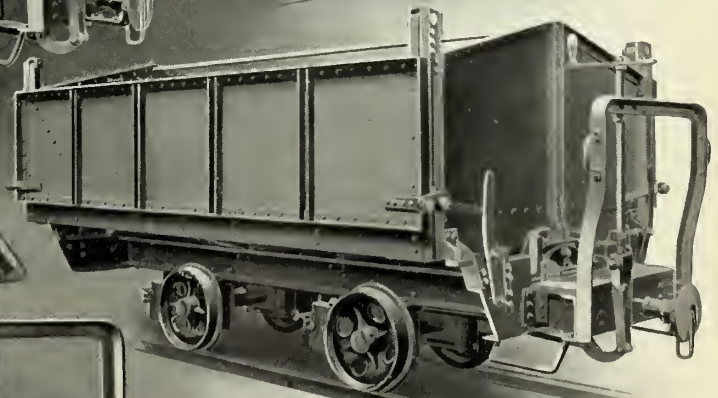
7674



7672



7675



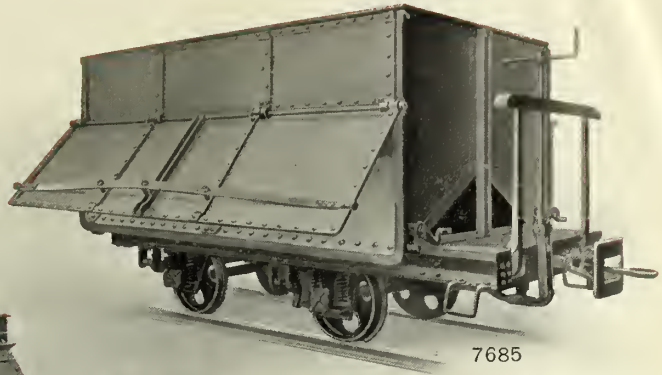
7673

Gable Bottom Cars are constructed with gable floors. They dump simultaneously to both sides, the dump being automatically caused by the release of levers. They are manufactured for either light or heavy service, for any required gauge and capacities up to 40 cu. yds. The under frame work may be made of wood as shown in Fig. 7681, or of a heavy channel steel as shown in Fig. 7682.

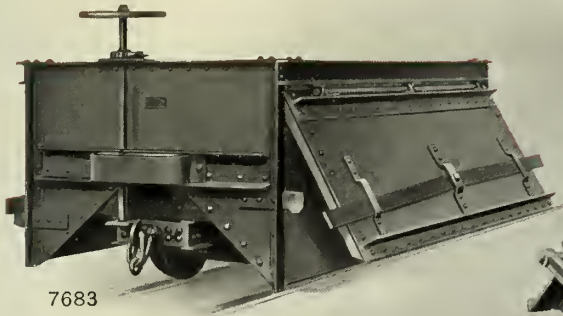
Fig. 7663 shows an exceedingly low construction. This type of car is especially adaptable where the head room is limited.

Fig. 7684 shows a type of car for the carrying of heavy loads. This car is built low and long and is equipped with double trucks and spring bumpers.

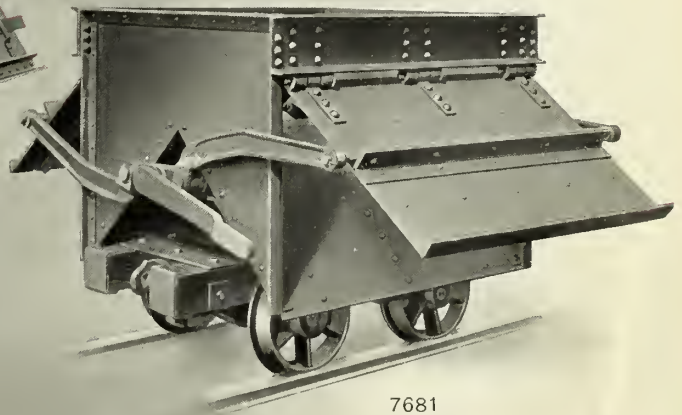
Fig. 7685 shows a car with spring bumpers, screw brake, and brakeman platform.



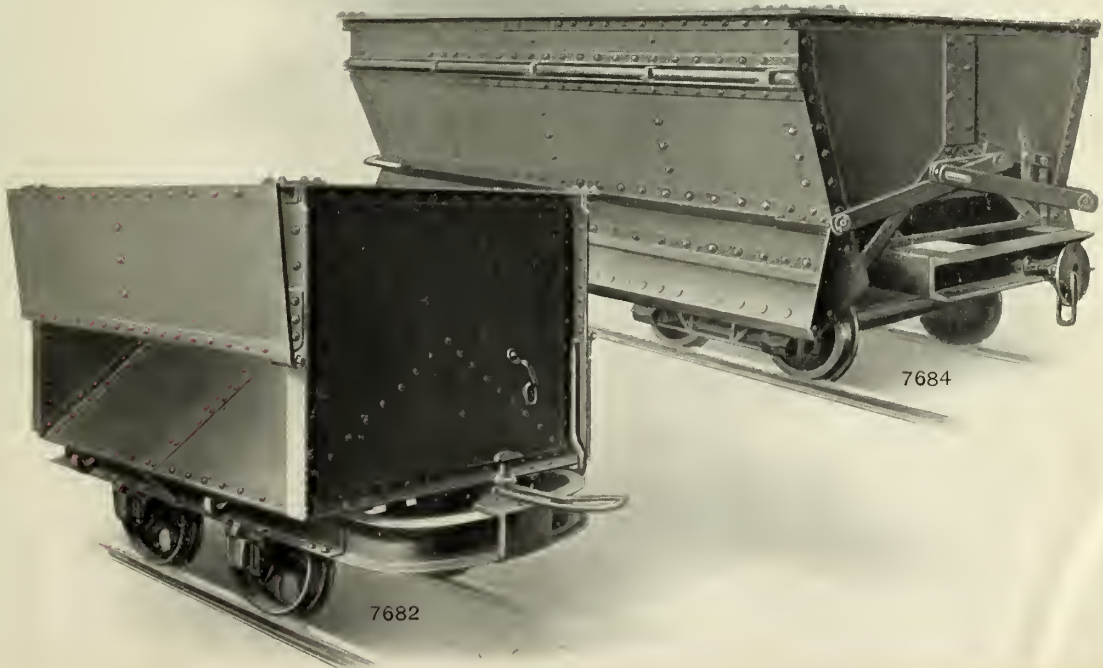
7685



7683



7681



7682

7684

Square Wood Box Dump Cars are made to dump on both sides or end. They are made in practically all gauges and capacities. They are built of strong body framing and have tough timber flooring. The doors are cross-braced and trussed together, but are pivoted and not subject to shocks. If a rock in the load hits the door it can swing out of the way freely. This is a great advantage over a rigid door. These cars are made with either a single or double truck.

When hauling with a "dinkey" the double truck car has the advantage of being shorter than two single truck cars where they have the same capacity as the double truck. A six-car train of 8 yd. double truck cars is 47-ft. shorter than a twelve-car train of 4 yd. cars and it carries 12 cu. yd. more material. An 18-ton "dinkey" will haul eight 8-yd. cars or fourteen 4-yd. cars. The eight-car train carries 23.8 cu. yds. more material and is 9 ft. shorter than the 14-car train. The additional capacity is due to heaping up the material on the car. With the double truck-car, time is saved in spotting.

SQUARE WOOD BOX DUMP CARS
CARROS DE VOLTEO CON CAJON CUADRADO, DE MADERA

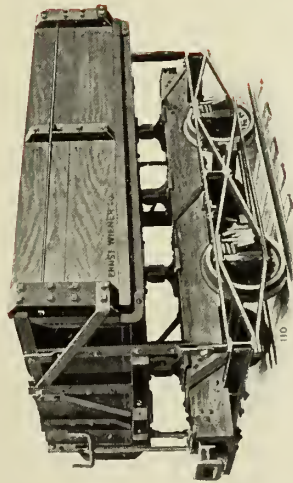


Fig. 110.
Diamond frame, one side dump car.
Carro de volteo á un lado con carretilla "Diamond."

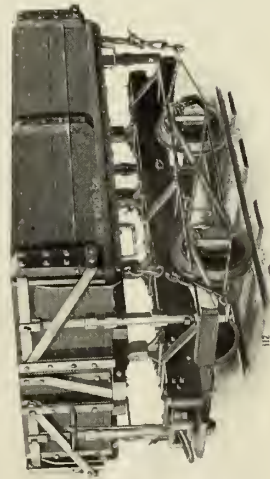


Fig. 112.
Diamond frame double side dump car.
Carro de volteo á dos lados con carretilla "Diamond."

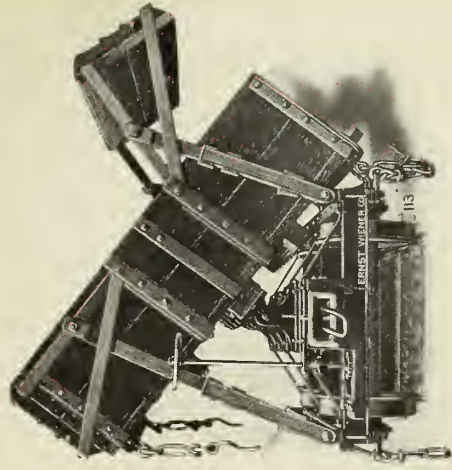


Fig. 113.
Same as fig. 112, but in a dumped position.
El mismo que la fig. 112, pero en posición volcada.

SQUARE WOOD BOX DUMP CARS
CARROS DE VOLTEO CON CAJON CUADRADO, DE MADERA

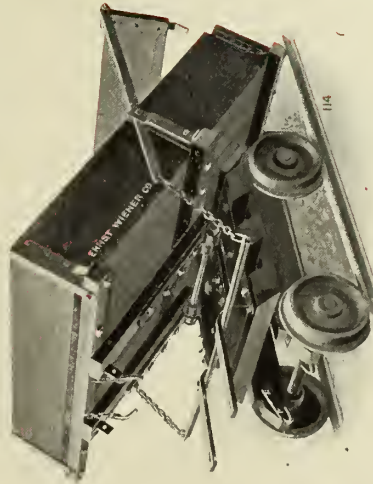


Fig. 114.
Rotary dump car, 1 1/2 yard capacity,
36" gauge.
Carro de volteo, giratorio de 1 1/2 yarda de
capacidad 36" ancho de via.

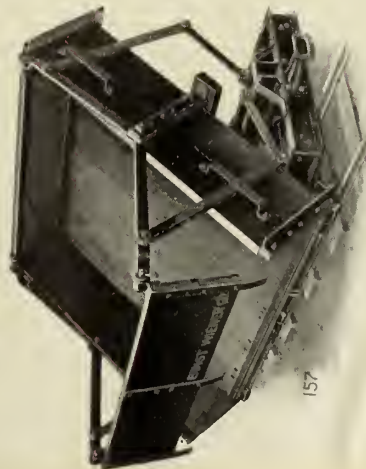


Fig. 157.
Double side dump car.
Carro de volteo a ambos lados.

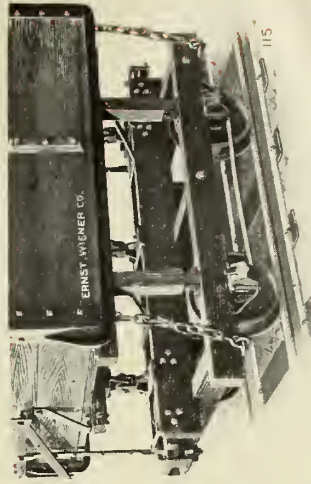
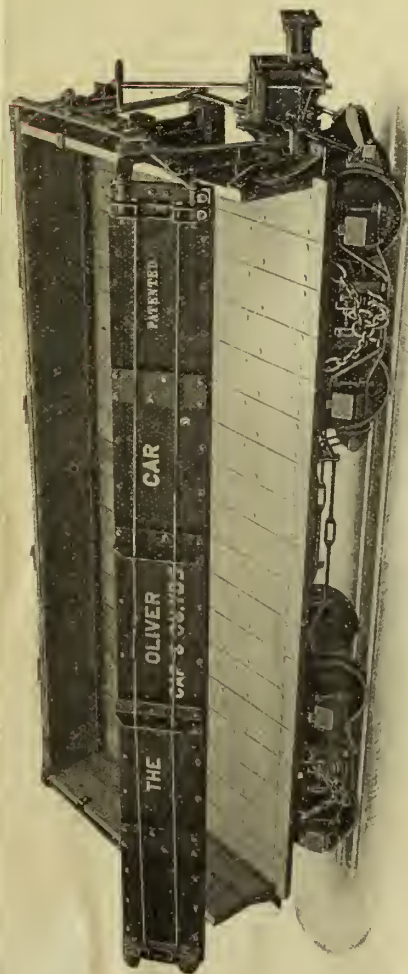
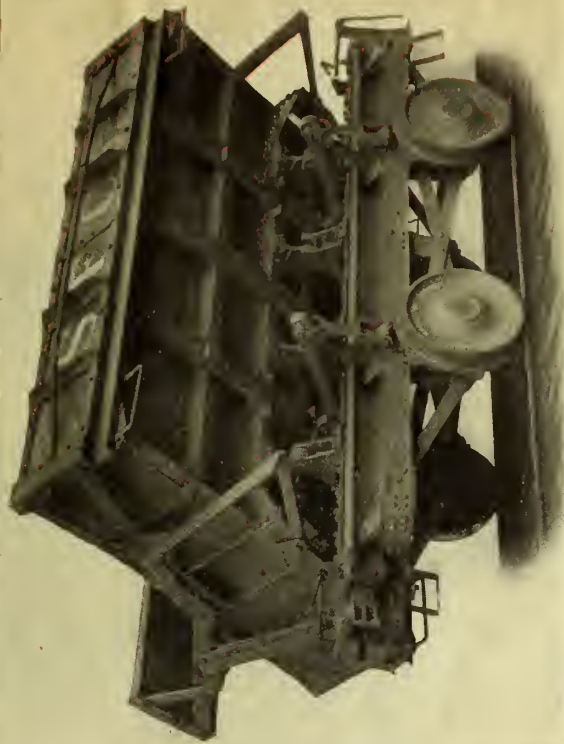


Fig. 115.
Wood sill one side dump car, 1 1/2 yard
capacity, 36" gauge.
Carro de volteo a un lado, con soleras de
madera, de 1 1/2 yarda de capacidad, 36"
ancho de via.



An 8-Yard Oliver in Dumped Position
(It Dumps on the Opposite Side Also)



60.



"CONTINENTAL" DUMP CARS

14-20 yards capacity, any gauge

Continental Car & Equipment Company (Inc.)

17 Battery Place, New York, N. Y.

Highland Park, Louisville, Ky.

An idea of the cost of moving earth with small cars is given by the following data.

The information was given by Mr. A. William Sperry, engineer and contractor, the work having been done under Mr. Sperry's direction.

The cars used on the work were all steel dump cars, manufactured by the Arthur Koppel Company, of Pittsburgh and New York. Six to nine cars were used, of 36 cu. ft. capacity, running on a 24-in. gauge track. These cars weigh 900 lbs. and stand 4 ft. 2 in. above the top of the rail. They cost about \$80.00 apiece. The rail used was of 20 lb. section, costing about \$30.00 per ton.

The excavation was made from a borrow pit alongside a railroad track, with the result that no ties were needed for the dirt track, but the rails were laid directly on the old ties and between the rails of the standard gauge track. In all 2,000 lin. ft. of track were used.

There were 7,000 cu. yds. of material taken from the lower pit, and hauled an average of 1,000 ft., down grade, about one-half being a 2 per cent grade and the other half a 4 per cent grade. In making the fill, at times the rail was laid on grades as high as 8 or 10 per cent. The cars would readily coast from the lower pit, and were drawn back by horses.

The material was a glacial deposit, containing from 15 to 50 per cent of large boulders, fully 50 per cent of which had to be blasted. The cost of blasting is included in the record of cost given below. These boulders prevented the material from being classed as earth. Under most specifications for excavation,

the material would have been classed as earth and loose rock.

The cars were taken to the dump in trains, a brakeman being used on each train. Three to four horses worked single, with a driver, hauled the cars back to the cut. One man was also used on the dump, and he also attended to the track work.

A 10-hr. day was worked and the following wages were paid:

Laborers, ...	\$1.40 to 1.65
Brakemen, ...	1.75
Dumpman, ...	1.75
Firemen, ...	3.00
Drillers, ...	1.65
Single horse and driver, . .	3.00

From 35 to 45 laborers were used on the work, from 3 to 6 drillers and 2 firemen. The firemen attended to the blasting. It was necessary to build a temporary trestle across a highway at a cost of \$195.00

The following is the cost per cu. yd. for each item of the work compiled from the total cost:

Loading cars, ...	\$0.215
Temporary trestle across highway,	0.015
Drillers, ...	0.035
Explosives, ...	0.010
Dumpmen and track work, ...	0.023
Horse and drivers, ...	0.045
Brakemen, ...	0.022
Freight and hauling on outfit, .	0.025
Depreciation of plant, (about	
7 1/2 per cent, ...	0.015
Superintendence, ...	<u>0.015</u>

Total, ... \$ 0.420

Owing to the large number of boulders in this work, scrapers could not have been used in excavating the material. The boulders too, were very hard on the cars; nevertheless the cars stood up well under the work. Owing to the down grade the cars were much more economical in doing this work than either dump carts or wagons would have been.

The track work cost about \$80.00 for this job, this making an average cost of 4 cts. per lin. ft. of track laid and taken up; but it must be remembered that no ties had to be laid.

It will be noticed that the cost of blasting was $4 \frac{1}{2}$ cts. per cu. yd. excavated, more than 75 per cent of the cost being for drilling. As there were only about 700 cu. yds. of boulders blasted, the cost per cu. yd. for blasting for the boulders actually blasted was 45 cts.

The hauling of the material cost nearly 0.7 cts. per cu. yd. per 100 ft. This is a very reasonable rate when the length of haul is taken into consideration.

Mr. J. B. Eveline, of Eveline Bros., contractors, gives the cost of excavating and transporting earth with small cars at Attleboro, Mass. The cars used were $1 \frac{1}{2}$ yard V-shaped, all steel cars. They were operated on a 30 in. gauge track, and were 4 ft. 5 in. high, and about 5 ft. 7 in. wide. These cars weigh 1,080 lbs. Some of them were equipped with brakes. The average cost of the cars was \$90.00, and as 40 were used, the total cost was about \$3,600.00. The cars were operated in trains of 4 cars, and coasted to the dump by gravity, being hauled back to the cut by one horse and a driver. Thus five horses were used for the 40

cars. The dead load pulled back by the horse was about 4,400 lbs. A 20-lb. rail was used, laid on wooden ties. In all, 2 1/2 miles of track was used on the job. Several turnouts and switches were used, thus allowing the cars to be kept almost continually in motion. Seventy tons of 20 lb. rails were used, and, at a price of \$32.00 per ton, the cost was \$2,240.00. The ties are only split ones or roughly hewn, and spaced on about 3 ft. centers. About 4,000 ties were used. At a cost of 12 1/2 cts. per tie, the total cost for ties was \$500.00. These ties could be used on several jobs. The total cost for plant outside of small tools was:

40 cars at \$90.00, ...	\$3,600.00
70 tons rails at \$32.00, ...	2,240.00
4,000 ties at 12 1/2 cts. . . .	<u>500.00</u>
Total, ...	6,340.00

Estimating, interest, depreciation, and repairs to the outfit at 2 per cent per month, we have a monthly charge of about \$127.00 for the plant.



Fig. 1—View Showing Excavation Work in Progress.

Fig. 1, ^{page 64,}

shows character of the material and also of the work that was done. The depth of cut averaged from 3 to 12 ft. The material was a boulder clay, consisting of loam, clay, gravel, and hardpan, and while most of it required but little loosening with picks, yet some of it had to be drilled with short holes and shot with 20 per cent dynamite. Some of the work where the banks were low, was worked from on top, but most of it was worked from abreast. Men shoveled the material with short handled shovels.

The excavated material was hauled from 700 to 1,000 ft., the average haul being about 850 ft. There were 80 men employed on the job working under 3 foremen. The wages paid for a 10-hour day were as follows:

Foreman, ...	\$3.00
Laborers, ...	1.80
Drivers, ...	1.80
Horse, ...	1.00

During the month of June in 25 working days, 15,000 cu. yds. of material were excavated. The total cost for this work was as follows:

3 foremen, 25 days, ...	\$ 375.00
75 men, 25 days, ...	3,375.00
5 drivers, 25 days, ...	225.00
5 horses, 25 days, ...	125.00
300 lbs. dynamite at 10 cts., ...	30.00
Plant charges, (estimated)	<u>127.00</u>

Total, ... \$4,257.00

This includes all cost except general expenses, and the month's proportion for laying track. The cost per cu. yd.

Foreman, ...	\$ 0.025
Loosening and loading,	0.225
Hauling, ...	0.023
Explosives, ...	0.002
Plant, ...	<u>0.008</u>
Total, ...	0.283

The wages on this job were high, but, taking these into consideration, the cost is low, for the length of haul. The item of transportation for an 850-ft. haul is very low, as compared to wagon hauling, since it amounts to only 1/4 ct. per cu. yd. per 100 ft. of haul. The largest item is that of loosening and loading, and with wages at \$1.50 per day this cost would be reduced nearly 4 cts. per cu. yd. The charge of a dollar per day for a horse, covers feed and care, as well as interest and depreciation.

HAULING WITH DINKEYS. - Small locomotives or "dinkeys" are used to furnish the motive power where large wooden or steel cars and steam shovels are used on excavation. The ordinary "dinkey" travels on a track of 3-ft. gage. The size of dinkey commonly used weighs 8 short tons, and is listed as having a tractive pull of 2,900 lbs. on a level track. The loads that a dinkey can pull, however, are much overestimated in catalogues, due to too low rolling resistances assumed for cars. Catalogues give the resistance for traction as 6 1/2 lbs. per short ton but this applies only to the best of standard gauge railway tracks with heavy rails, well ballasted, and with heavy wheel loads. On a contractor's narrow

gauge, light rail track, the resistance to traction is probably not much less than 40 lbs. per ton, and at the place where the cars are loaded it is doubtless more, due to the dirt on the rails. Careful tests show that nine cars drawn in trains at 4 1/2 miles an hour showed from 26 to 66 lbs. resistance per ton on a level track; the 26 lbs. was only for very well lubricated cars drawn in trains of 20 cars. Short trains (2 to 4 cars) showed higher resistance than long trains, doubtless due to the greater effect of irregularities in the track, which are more or less counterbalanced in long trains.

Based upon the assumption that the resistance due to gravity is 20 lbs. per short ton on a 1 per cent grade, and that the tractive power of a locomotive falls off 20 lbs. for every ton of its own weight for each 1 per cent of grade, and that the resistance to traction is 40 lbs. per short ton, an 8-ton dinkey is capable of hauling the following loads, including the weight of the cars.

				Total tons.
Level track,	.	.	.	70
1 per cent grade,	.	.	.	46
2 " " "	.	.	.	33
3 " " "	.	.	.	26
4 " " "	.	.	.	21
5 " " "	.	.	.	17
6 " " "	.	.	.	14
8 " " "	.	.	.	10

When heavily loaded, a dinkey travels 5 miles per hr. on a straight track; but when lightly loaded, or on a down grade, it may run 9 miles an hour.

On short hauls (1,000 ft. or less), one dinkey often serves a 1 1/2 yd. shovel. In such cases the dinkey is

not heavily loaded, so that it can run fast, and by having enough men to dump a train of 6 cars in 2 or 3 mins., a fairly good daily output of the shovel can be secured.



STEAM SHOVELS.

- - - : - - -

In excavating material with a steal shovel it is necessary; first, to crowd the dipper forward into the material, with a horizontal motion; second, to hoist the dipper upward through the material. with a vertical motion. The dipper is suspended by an adjustable arm, hinged to a carriage or trolley moving horizontally along a trackway. The movement of the dipper is controlled by cables which run up over a wheel on the end of the boom and then down to a drum which is operated by an engine.

Some shovels are so designed as to require only one operator or engineman. Others require two enginemen for successful operation.

In addition to the well known function of the steam shovel in railroad excavation and open cut mining, it is likewise used to load blasted rock in stone and cement quarries; also to dig shale and stiff clay for use in brick plants. Furthermore, in sand and gravel pits and in loading iron ore, it has been found to be the most economical machine. Steam shovels are of two types, namely; those in which the boom swings 90° to either side and the body of the shovel remains stationary; and those which revolve through a complete circle, thus enabling them to dig and dump on all sides. Where the excavated material is of value, as in railroad work where the material is used in making a fill, the first named type is used. In trench or canal work, where the material is thrown out upon a spoil bank, the revolving steam shovel is most advantageously used.

The size of shovel to select for any given work de-

pend upon the yardage of earth in each cut and not upon the total yardage in the contract. A small 26-ton traction shovel with 1-yd. dipper should be used for small cuts, where moves from one cut to another will be frequent. A 55 to 65-ton shovel with 1 1/2 to 2 1/2 yd. dipper gives the best results where the cuts are heavy, and moves are not very frequent. A 75 to 90-ton shovel, with 2 1/2 to 3 1/2 yd. dipper should be used on heavy cuts, where moves are infrequent. In hardpan, shale and tough materials, a heavy shovel with a small dipper is necessary. In steam shovel work, the larger the capacity the smaller the cost per cu. yd; hence, the larger shovel may be operated in certain kinds of material at a greatly reduced cost, as compared with one of the smaller machines. Advertising catalogues usually give the size of steam shovels by the capacity of the dipper in cubic yards and the weight of the whole machine in tons; both shovels should be given for in a hard material a smaller dipper is used than in a soft material when working with the same steam shovel. A shovel of any size is so designed that, when digging in ordinary earth, it can average 3 dipperfulls per minute, when the dipper arm swings only 90°. A revolving shovel, digging in average earth, will average two dipperfulls per minute. Shovels are built to run on standard gauge track, and in operating a shovel it is customary to use rails in 5-ft. lengths, so that the shovel cuts 5-ft. into a face before it is shifted ahead. The time required to shift ahead may average as low as 3 mins., and should never average more than 5 minutes.

The following are some of the standard sizes:

Weight in tons.	Dipper cu.yds.	Coal in 10-hrs. in tons.	Water in 10-hrs. in gallons.
35	1 1/4	3/4	1,500
45	1 1/2	1	2,000
55	1 3/4	1 1/4	2,500
65	2	1 1/2	3,000
75	2 1/2	2	4,000
90	3	2 1/4	4,500

The size of dippers, as listed in catalogues, refers to dippers heaped full of loose earth. The actual place measure averages from 20 to 30 per cent less than the listed capacity of a dipper, for not every dipper goes out full, and even if it does the earth is not as compact in the dipper as in place.

On the basis of 2 dippers loaded per minute of actual work, we have the following for dippers of different sizes:

Dipper		Output in Cubic Yards.	
Nominal Yds.	Actual. (Average). Yds.	Steadily, 10 hrs.	Shoveling 5 hrs.
1	.7	840	420
1 1/2	1.0	1200	600
2	1.4	1680	840
2 1/2	1.7	2040	1020

Occasionally, under exceptionally favorable conditions, a shovel may average 6 or 6 1/2 hrs. of actual shoveling per 10-

hr. day, but 5 hrs. out of 10 is a very good average. The necessary delays of shifting the shovel ahead, switching the trains, moving the shovel back to start a new swath, etc., keep the shovel idle about half the time.

The width of the cut or swath excavated by a shovel varies from 18 ft. for the smallest shovels to 40 ft. for the largest. The height of the face in tough material should not be higher than the dipper can reach, that is, 14 to 20 ft. Too high a face is treacherous, for the shovel may be buried by a slide.

The height of the face of the cut has a marked influence on the output of a shovel. Shallow cuts are expensive not only on account of frequent moves, but because a full dipper cannot be averaged where the height of the face of the cut becomes much less than one and a half or two times the depth of the bucket.

In addition to the lost time of shifting the shovel, there is more or less lost time switching cars up to the shovel. On "through cut" work this lost time of switching is greater than on "side cut" work. On "through cut" work only one or two cars can come up on the track alongside the shovel, the car track being in the bottom of the cut. In "side cut" work a full train of cars can come alongside the shovel, one car being loaded after another until the train is loaded.

Traction shovels weighing 26 tons, or less, may be had, and they do not require rails to run upon, but are provided with broad-tired traction wheels. In shallow work where

moves are frequent, the traction shovel can be used to the best advantage.

There are frequently conditions that make it cheaper to use wagons instead of cars for hauling the earth away. In such cases a large dipper should never be used, for so much earth would spill over the sides of the wagon as to block the road and delay the movement of the wagons, even when a snatch team is used. A 1 1/2 yd. bucket is as large as should be used for loading wagons.

Gillette states that the cost of operating a 55-ton shovel is ordinarily about as follows:

1 foreman, ...	\$ 5.00
1 engineman, ...	4.00
1 craneman, ...	3.50
1 fireman, ...	2.00
6 pitmen, at \$1.50, ...	9.00
1 night watchman, ...	2.50
2 enginemen on 2 dinkeys, at \$3.00, ...	6.00
2 trainmen, at \$2.00, ...	4.00
4 dumpmen, at \$1.50, ...	6.00
10 trackmen, at \$1.50, ...	15.00
1 pumpman, ...	2.50
4 blacksmiths, carpenters, etc., on repairs, ...	12.00
2 water boys, at \$1.00, ...	2.00
Supplies for repairs, ...	6.00
Coal, 1.3 tons for 1 shovel, at \$4.00, ...	5.20
Coal, 0.6 ton for 2 dinkeys, at \$4.00, ...	2.40
Coal, 0.2 ton for 1 pump to supply water, ...	0.80
Oil and waste, ...	1.00
15 per cent interest and depreciation on \$15,000 plant, distributed over 150 days worked per year, ...	<u>15.00</u>

Total, per 10-hr day, . . . \$ 103.90

The 10 trackmen are engaged in grading for new tracks, track-shifting, etc. The 4-dumpmen must be increased to 8 dumpmen where the material is not dumped through trestles, and where long trains are hauled. The 6 pitmen keep the bottom of

the pit level for the shovel track, shift the sections of track, clear away the spilled material from the car track, etc. In heavy cuts requiring infrequent shifting of tracks, and where tracks are well laid the number of trackmen may be reduced.

Estimating the daily output of a 55-ton shovel as 900 cu. yds. the cost is slightly less than 12 cts. per cu.yd. In this case the shovel, was considered to make three dipper-fuls per minute.

SAVING IN TEAM TIME EFFECTED BY THE STEAM SHOVEL. - Any comparison between the steam shovel and hand labor must be considered as approximate and subject to rather wide variations, depending upon the nature of the material being handled, the efficiency of the labor and the special conditions under which the work is being presented. The more difficult the material, the greater the advantage for the shovel, whose output is not so seriously affected in rough stony work as is that of the hand shoveller.

Six to eight men will load a two yard wagon in from six to twelve minutes, say eight minutes as an average.

The shovel will load the same wagon in one to two minutes, an average saving of six minutes per wagon or three minutes per yard.

The great advantage of the shovel for getting teams away quickly when bunched and thus overcoming a frequent source of trouble in team work will be appreciated. When teams are so bunched the delay in loading by hand affects not alone the team being loaded but the others that are waiting.

It is believed that an average saving of three minutes per yard for the shovel is conservative.

GAIN IN TIME FOR VARIOUS OUTPUTS.

400 yds. per day at 3 minutes-	1200 min. or 20 hrs. at 45¢,	9.00
500 " " " " " "	1500 " " 25 " " "	11.25
600 " " " " " "	1800 " " 30 " " "	13.50

COST OF OPERATING THE SHOVEL.

No. 0 shovel for 400 to 500 yards.

Wages of operator,	3.00 to 4.00
" " fireman,	1.75 to 2.00
" " two laborers,	3.00 to 3.50
1/2 ton of coal,	1.50 to 2.00
Oil and supplies,	<u>.50 to 1.00</u>

Total, 9.75 to 12.50

No. 1 shovel for 500 to 600 yards.

Wages of operator,	3.50 to 5.00
" " fireman,	1.75 to 2.00
" " two laborers,	3.00 to 3.50
3/4 ton coal,	2.25 to 3.00
Oil and supplies,	<u>.75 to 1.00</u>

Total, 11.25 to 14.50

It will be noted that the estimated saving in team time practically equals the cost shown for operating the shovel. If this is true the economy actually derived from the shovel would equal the entire cost of loading by hand methods and which may run from 12 cents to 25 cents per yard depending upon conditions.

SAVING EFFECTED WITH STEAM SHOVEL DAILY.

Output 400 yards -	If hand loading costs	10 cents,	40.00
"	"	" 12 "	48.00
"	"	" 15 "	60.00
"	"	" 20 "	80.00
Output 500 yards -	"	" 10 "	50.00
"	"	" 12 "	60.00
"	"	" 15 "	75.00
Output 600 yards -	"	" 10 "	60.00
"	"	" 12 "	72.00

SAVING EFFECTED WITH STEAM SHOVEL ON JOBS.

Total yardage 5000 -	If hand loading costs	10 cents,	500.00
"	"	" 12 "	600.00
"	"	" 15 "	750.00
"	"	" 20 "	1000.00
Total yardage 10000-	"	" 10 "	1000.00
"	"	" 12 "	1200.00
"	"	" 15 "	1500.00
Total yardage 20000-	"	" 10 "	2000.00
"	"	" 12 "	2400.00
"	"	" 15 "	3000.00
Total yardage 40000-	"	" 10 "	4000.00
"	"	" 12 "	4800.00
"	"	" 15 "	6000.00

Many contractors permit the shovel to save its entire purchase price or more.

This value corresponds closely to the following steam shovel work done at Newcomb Pit, on the Chicago, Milwaukee and St. Paul R.R.

STATEMENT OF STEAM SHOVEL WORK ON THE CHICAGO MILWAUKEE AND ST. PAUL R.R. AT NEWCOMB PIT DURING THE MONTH OF MARCH, 1909.

Shovel - BUCYRUS, No. 453, 2 1/2 yd. dipper, 65-tons.
Engines - Prairie type, 3 in use; tractive power, 33,300 lbs.
Cars - Western dump, average load 12.6 yds.
Trains - One engine handling 13 leads, and a caboose per train.
Yardage - 68,000 cu. yds. handled in 27 working days, 10 hrs. each.
Yard Miles - 308,780
Average haul - 4.54 miles. Rate of ascending grade against

loads, 88.00 ft. per mile.

TOTAL COST, LABOR -

Steam shovel roll	1815.64	
Section labor, ...	99.94	1915.58

WORK TRAIN SERVICE -

Conductors, 95.8 at 3.68.	352.54	
Brakemen, 191.6 at 2.53	484.75	
Engineers, 95.8 at 4.40	421.52	
Firemen, 95.8 at 2.95	282.61	
768 tons coal at 4.00	3072.00	
1,906,000 gal. water (255,466 cu.ft at .07 - 100 ft.)	178.83	
95.8 Eng. days for supplies at .32	30.66	
81.0 Eng. days for depreciation at 2.03.	164.43	
81.0 Eng. days for repairs at 3.00	243.00	
81.0 Eng. days for interest at 2.03.	164.43	5394.77

COAL USED BY STEAM SHOVEL.

172.8 tons at 4.00	691.20
	<u>8001.55</u>

LESS CAMP CREDITS (PROFITS) -

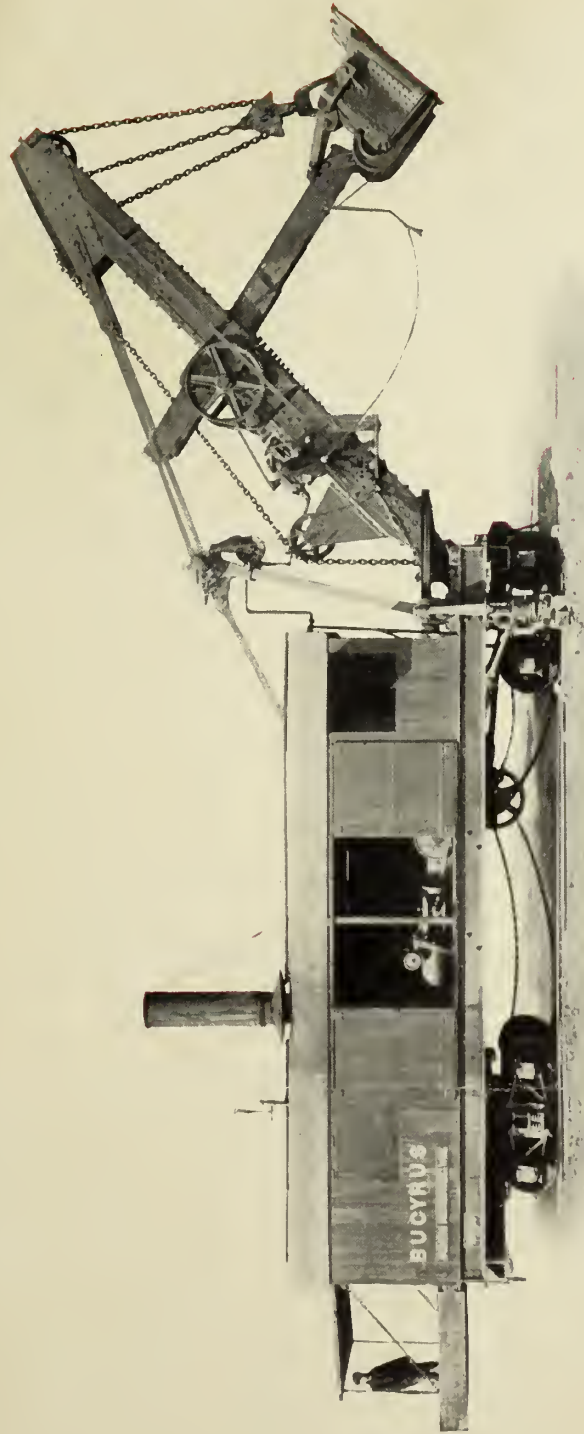
Boarding camp, ...	174.27	
Commissary, ...	<u>15.74</u>	190.01
		<u>7811.54</u>

68,000 cu. yds. handled during month -
 $\$7811.54 \div 68,000 = \$0.1148$ per yard.

The material cars used in the above work were Western Air Dump Cars of 12 yds. capacity.

(Note. - It will be noted that the cars were dumped and brought back to place by air, operated from the engine, no laborers being used, the conductor and brakeman unfastening and fastening the chains which hold the beds in position. On account of the location of this particular work the cost of coal was very high and March weather conditions are not favorable to doing work at minimum costs.)

The above is an exceptionally good record and the average contractor would probably not do as well. The 65 ton machine is no longer manufactured but the 70-C corresponds to it in point of engine power and efficiency.



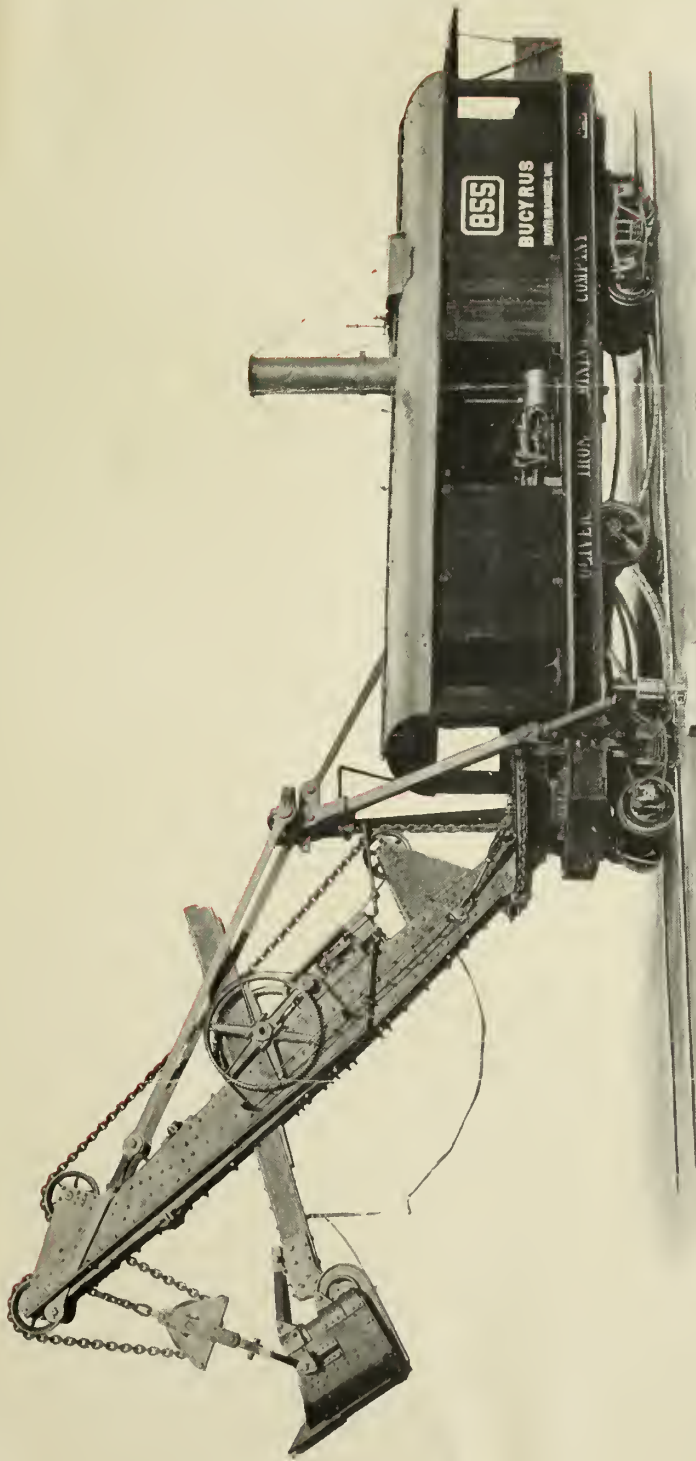
SEVENTY C BUCYRUS STEAM SHOVEL

The cost of loading blasted rock in a stone quarry with the 70-C would be about 3 cts. per cu. yd. The capacity in a day of 10 hours would be in the neighborhood of 1200 yards. The following table gives approximate cost of loading blasted rock:

1 engineer, ...	\$ 125.00
1 craneman, ...	90.00
1 watchman, ...	60.00
1 fireman, ...	60.00
4 pitmen, ...	182.00
Coal, allowing two tons per day, at \$3.50 per ton, ...	182.00
Oils, waste, and supplies, . . .	15.00
Repairs and renewals, ...	50.00
Interest on investment - per month, ...	<u>50.00</u>
Total, ...	\$ 814.00

\$814.00 divided by 26 days equals 31 and a fraction, which makes the cost \$.026 per yard.

The 95-C, the weight of which is about 107 tons, has mined in the neighborhood of 5000 tons a day, at a cost of about 2¢ per ton.



NINETY-FIVE B BUCYRUS STEAM SHOVEL

The following tables give an estimate of cost of handling earth with Thew No.0 and No.1 shovels when there is a full and a limited output.

ESTIMATED COST OF HANDLING MATERIAL

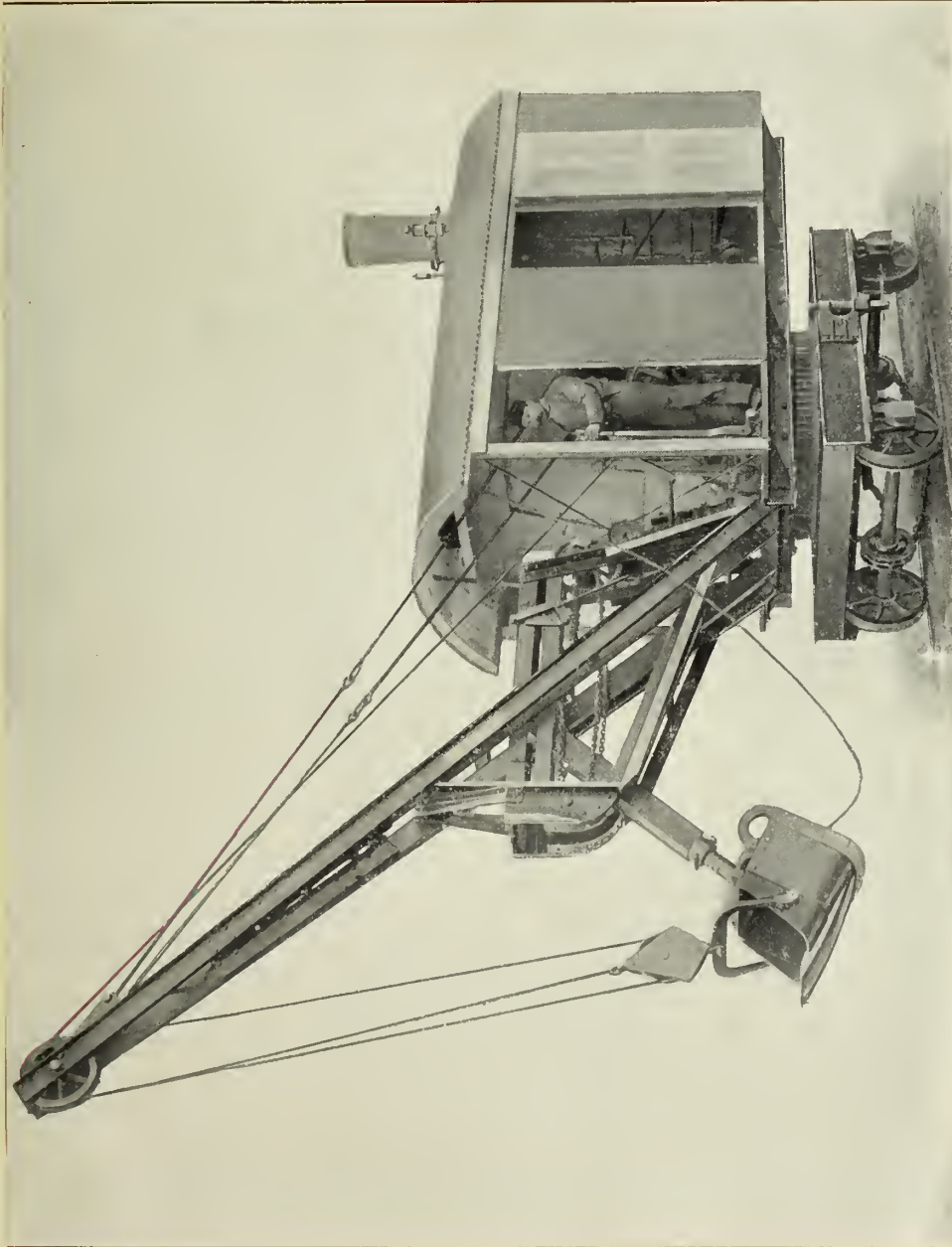
WITH NO.0 and NO.1 SHOVELS.

Type No. 0 Shovel.

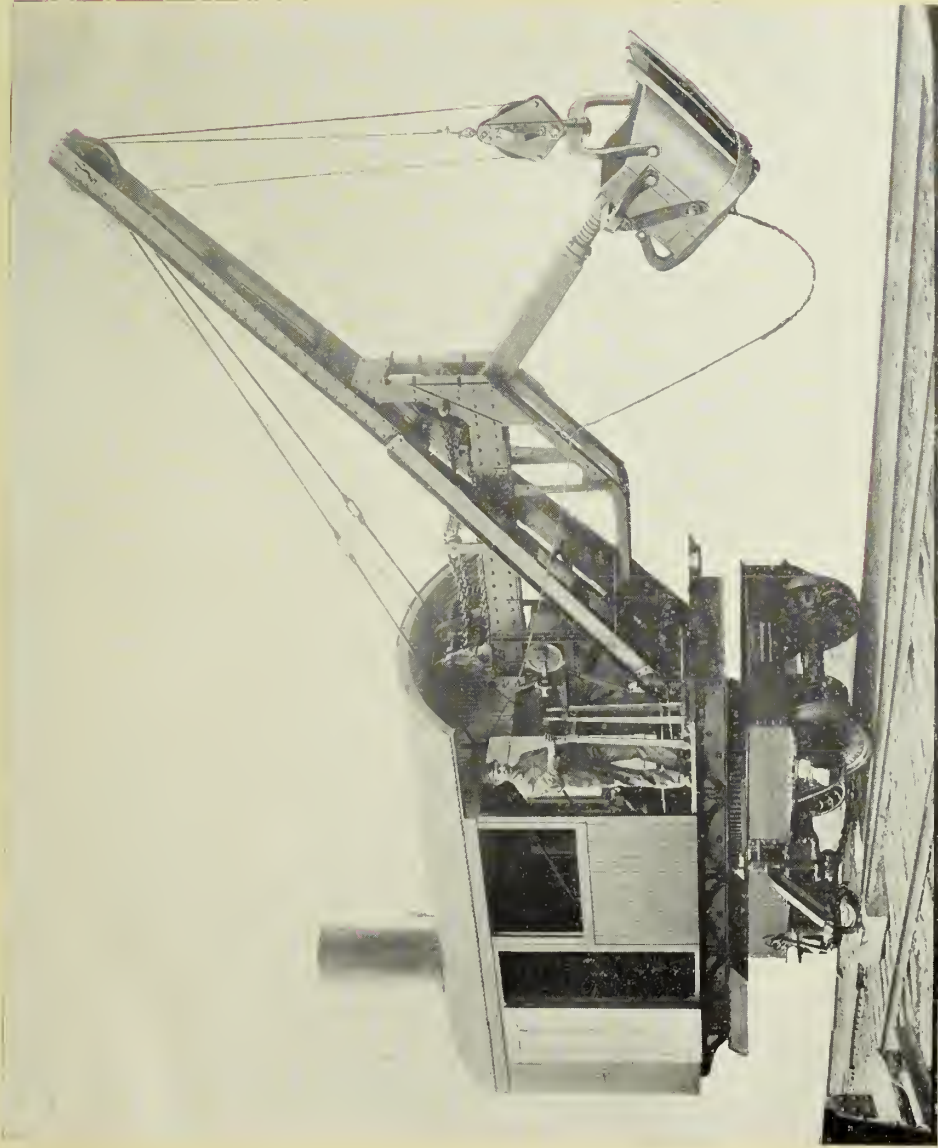
	Full output.		Limited output.	
Wages of engineer, ...	3.00	to 4.00	2.50	to 3.50
" " fireman, ...	1.75	to 2.00	None.	
" " laborers, (2) . .	3.00	to 3.50	(1) 1.50	to 1.75
Steam coal, (1000 lbs) . .	1.50	to 2.00	1.25	to 1.50
Oil, supplies, and repairs	.50	to .75	.30	to .50
	9.75	to 12.25	5.55	to 7.25
Allowance for interest and depreciation, .	1.50	to 2.50	1.50	to 2.50
	11.25	to 14.75	7.05	to 9.75
Estimated output,	300	to 400	150	to 175
Cost per yard,	4¢	to 5¢	4¢	to 5 1/2¢

Type No. 1 Shovel.

Wages of engineer, ...	3.00	to 4.00	2.50	to 3.50
" " fireman, ...	1.75	to 2.00	None.	
Laborers on ground, (2) . .	3.00	to 3.50	(1) 1.50	to 1.75
Steam coal, (2000 lbs) . .	3.00	to 4.00	2.50	to 3.00
Oil, supplies, and repairs	.50	to 1.00	.50	to .75
	11.25	to 14.50	7.00	to 9.00
Allowance for interest and depreciation, .	2.00	to 3.00	2.00	to 3.00
	13.25	to 17.50	9.00	to 12.00
Estimated output,	500	to 600	200	to 300
Cost per yard,	2 1/2¢	to 3 1/2¢	3¢	to 6¢



Type No. 0 Full Circle Swing Shovel—Mounted Upon Car Wheels or Traction Wheels



Type No. 1 Full Circle Swing Shovel—Mounted Upon Car Wheels or Traction Wheels.

The Sibley Quarry Company of Sibley, Michigan, use a Giant Class A 120 ton shovel with a 5-yd. dipper for loading blasted rock into cars. The material is blue and gray lime rock, which is blasted before loading and the shovels work in a face of this rock about 35 feet high. When the rock is blasted, some of the pieces are left as large as five cubic yards in size. These are picked up by the shovel and thrown over to one side, where they are reblasted to a size acceptable to their crusher plant. The balance of the material is loaded by the shovel into 4-yd. dump cars. They give the cost of loading this rock as about 8 cts. per cu. yd.

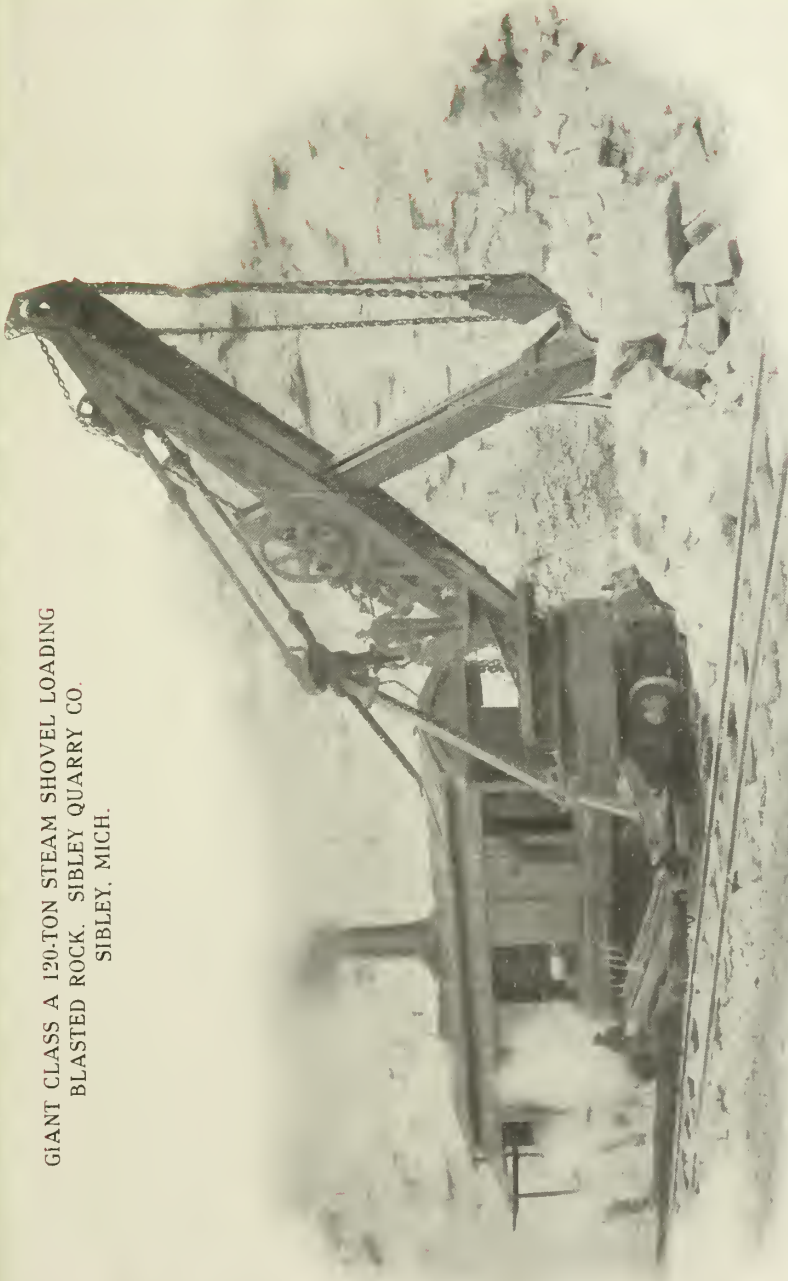
In the manufacture of cement heavy duty steam shovels are used. The following table indicates the size of dipper to be used with heavy duty shovels working in shale, loose or blasted rock:

120 tons,	5 cu. yd. dipper.
110 "	4 " " "
95 "	3 1/2 " "
75 "	2 1/2 " "
65 "	2 " "
45 "	1 1/2 " "

This shows the size of the dipper to be small in comparison to that used when the shovel is working in average earth.

The Burt Portland Cement Company, of Bellevue, Mich., use a 120-ton shovel with a 5-yd. dipper for loading cement rock without blasting. The cost of this work, over a period of several years, has averaged about 12 cts. per cu. yd.

GIANT CLASS A 120-TON STEAM SHOVEL LOADING
BLASTED ROCK. SIBLEY QUARRY CO.
SIBLEY, MICH.





GIANT CLASS A 120-TON STEAM SHOVEL DIGGING CEMENT ROCK WITHOUT BLASTING.
BURT PORTLAND CEMENT CO., BELLEVUE, MICH.



LITTLE GIANT STANDARD STEAM SHOVEL LOADING BLASTED ROCK. BUFFALO CEMENT CO.

1910-1911

Problem 4. Design of a Reinforced Concrete Elastic Arch Ring.

General Instructions.

Size of drawing sheet is 22" x 30"; border 20" x 28". Use a hard pencil and draw sharp lines so that distances may be scaled closely.

Scale of Arch Ring: 1" = 2'; scale of force polygon: 1" = 2000#

Draw the arch ring in the upper left corner of the sheet.

Draw the force polygon immediately below the arch.

Data.

Clear span = 30'; rise = 6'; $f_c = 500\#$; $f_s = 15000\#$; shear in concrete alone = 40%; in reinforced concrete = 100%; bond stress = 80%; $n = 15$; $E_s = 30,000,000$. No tension is allowed in the concrete. Use $P = .006$.

Dead Load: Concrete = 150# per cu. ft., earth filling 100# per cu. ft. Earth fill is 2 foot thick at the crown.

Live Load: 200# per square foot. Assume the live load as extending over only the right half of the arch.

All loads are considered as acting vertically. No horizontal component of the earth pressure is considered.

Design:

1. Determine the thickness of the arch at the crown.

$$t = s + \frac{s}{10} + \frac{5}{1000} (\text{Live Load}) + \frac{25}{10000} (\text{Dead Load})$$

in inches.

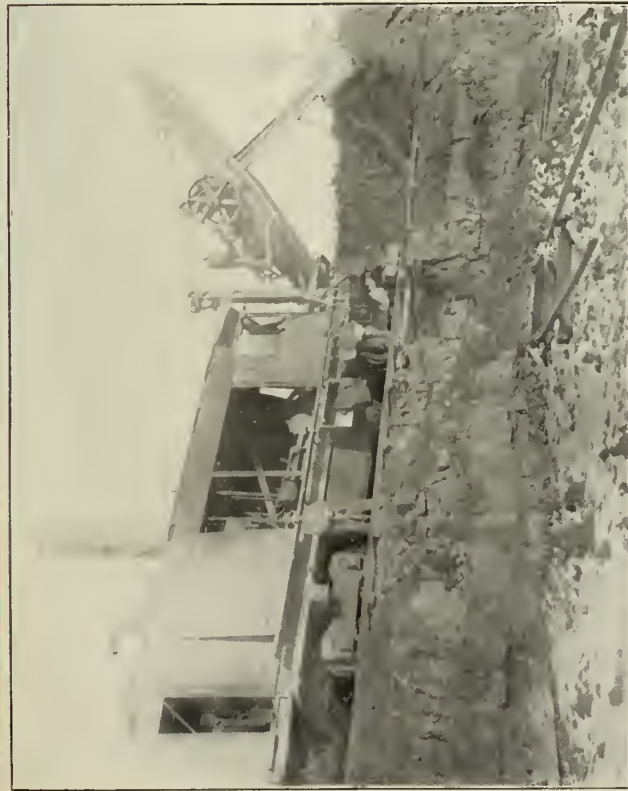
2. Lay out an arch ring having a three centered intrados and a circular segmental extrados, making the thickness at the springing line 2.5 t.
3. Draw the arch axis midway between intrados and extrados.
4. Divide the arch ring by planes at right angles to the axis of the ring, making $\frac{ds}{t}$ constant. Make at least five

divisions in each half of the arch ring. This may be done graphically or according to Art. 178, p. 341.

Assume the steel to be symmetrically placed, the distance between the centers of gravity of the two rows being 0.7 of the radial thickness.

5. Lay off the divisions upon the arch ring and number the divisions from left to right along the axis.

Handwritten text, likely bleed-through from the reverse side of the page. The text is extremely faint and illegible due to the quality of the scan and the nature of the bleed-through. It appears to be a list or a series of notes, possibly related to a botanical or scientific study, given the context of the document.



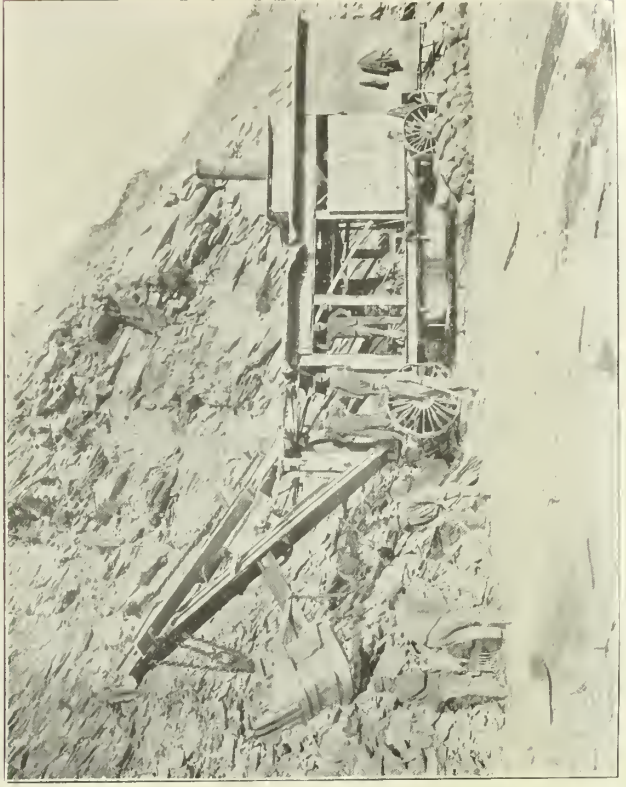
DIAMOND PORTLAND CEMENT CO., MIDDLEBRANCH, OHIO.



ALPHA PORTLAND CEMENT CO., EASTON, PA.



SPECIAL STRIPPING SHOVEL.



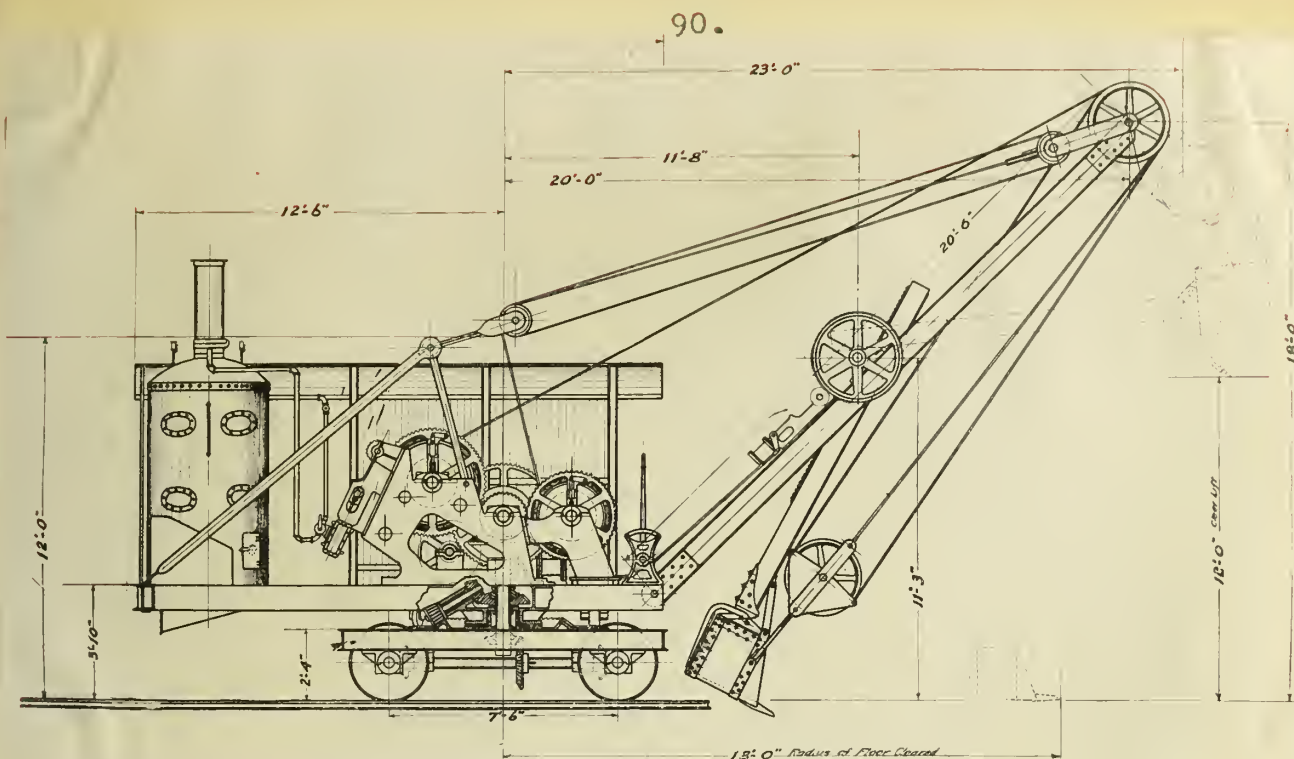
ALPHA PORTLAND CEMENT CO

SPECIAL STEAM SHOVELS of the revolving type are designed so that they can be operated by only one man. They are especially adapted for brick manufacturer's use. The following sizes are used by the smaller plants.

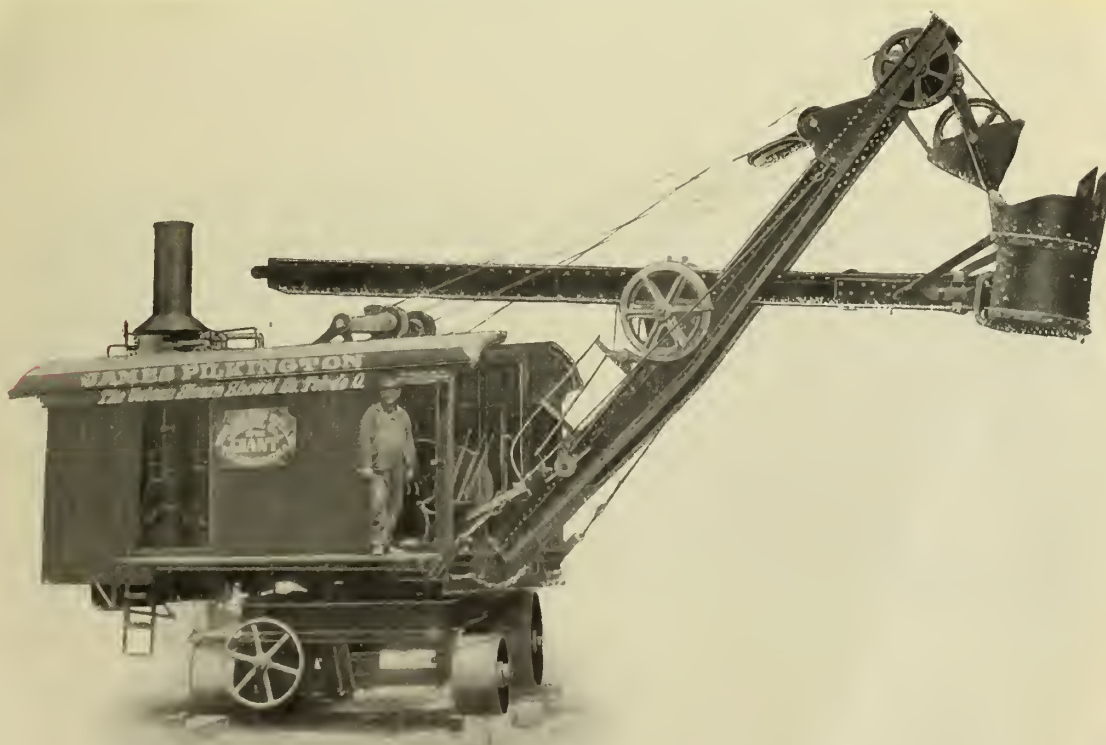
15 ton	1/2 yd. dipper
25 "	3/4 " "
30 "	1 " "
35 "	1 1/4 " "

The capacities of these shovels vary from 200 to 700 cu. yds. per 10-hr. day. These shovels though idle half of the time will load the clay at about 1/3 the cost of hand labor.

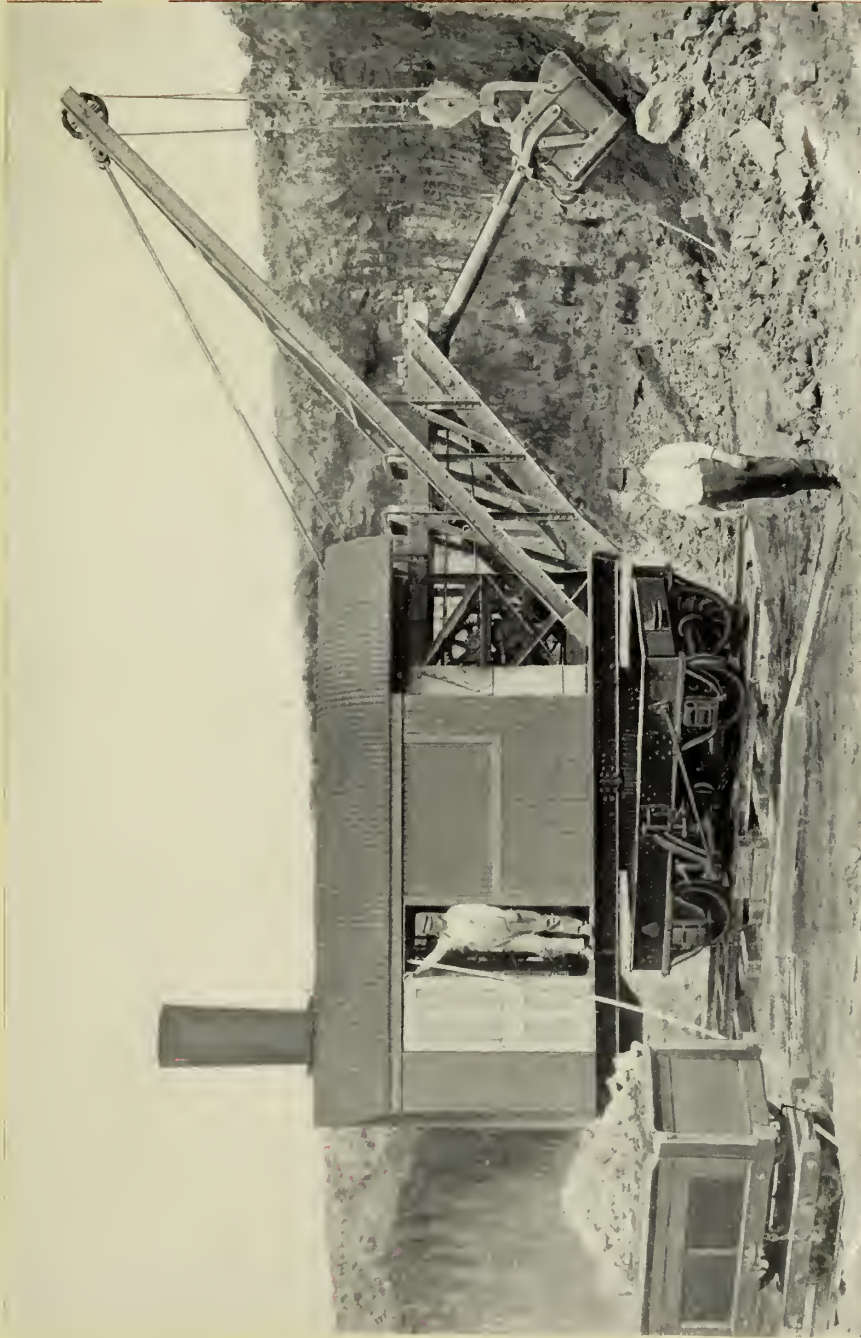
For brick plants of larger capacities, shovels ranging in sizes from 45 to 70 tons are used, the cost averaging about 3 cts. per cu. yd. in clay and about 5 cts. in shale.



GIANT No. 1 SPECIAL REVOLVING SHOVEL



GIANT No. 2 REVOLVING SHOVEL, equipped with long dipper handle for trench work. Owned by James Pilkington, New York,



No. 3 Shovel Excavating Clay for Brickyard



REVOLVING STEAM SHOVEL DIGGING CLAY. W. J. SPEAR, TOLEDO, OHIO



BOOM RAISED, SHOWING HIGH DUMP



LITTLE GIANT STEAM SHOVEL DIGGING CLAY. NATIONAL FIREPROOFING CO., HOBART, INDIANA



65-TON STEAM SHOVEL DIGGING SHALE. PITTSBURGH VITRIFIED PAVING BRICK AND TILE CO., PITTSBURGH, KANSAS



120-TON STEAM SHOVEL DIGGING SOLID SHALE WITHOUT BLASTING
COFFEYVILLE VITRIFIED BRICK AND TILE CO., CHERRYVALE, KANSAS



75-TON STEAM SHOVEL DIGGING SHALE WITHOUT BLASTING
COFFEYVILLE VITRIFIED BRICK AND TILE CO., COFFEYVILLE, KANSAS

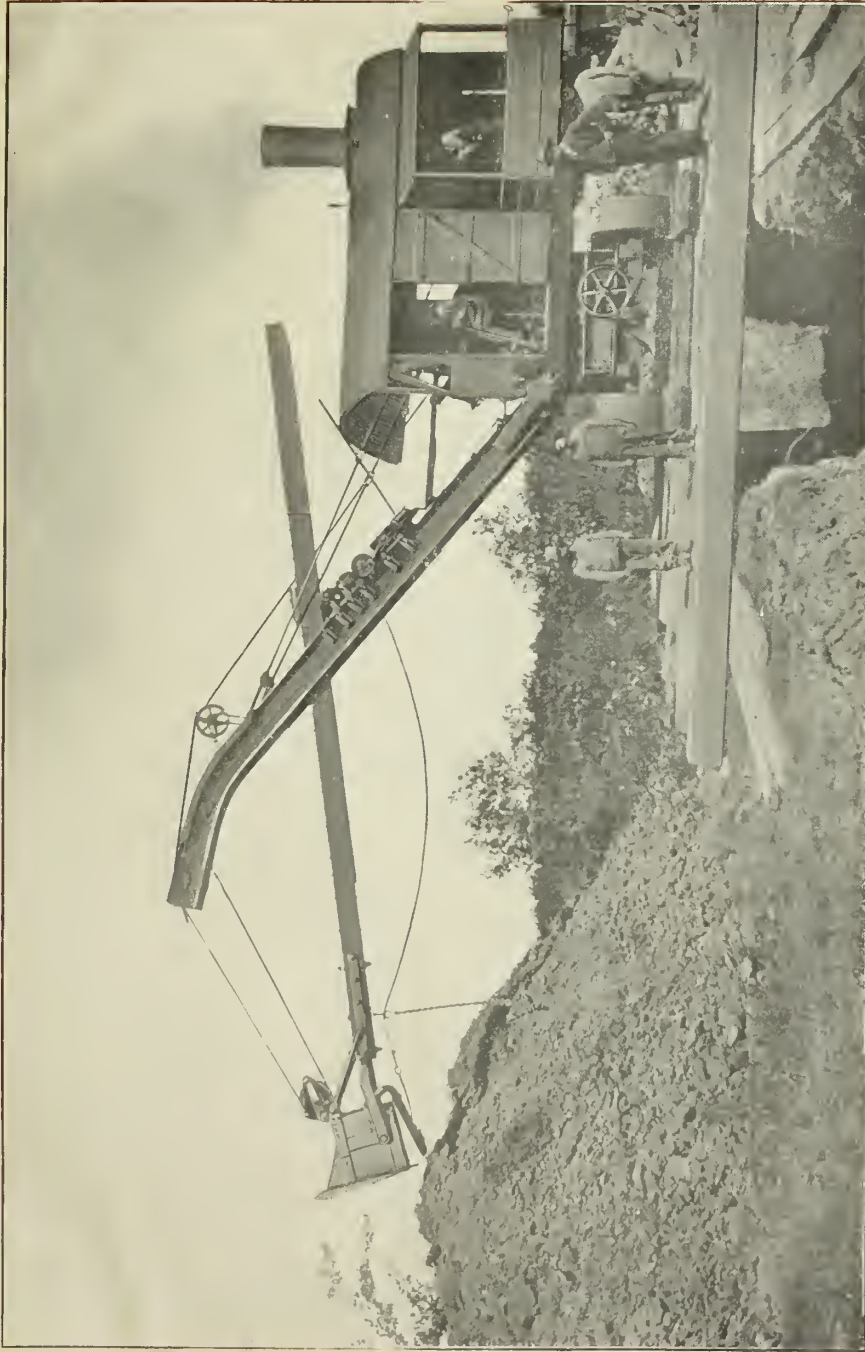
In cases where the conditions are favorable for a steam shovel on trench work, the shovel is equipped with a dipper handle from 20 to 30 feet long, which enables them to dig trenches from 3 to 20 feet wide and from 6 to 20 feet deep. Where small pipe lines are being laid the shovel digs the material at the front, and swings through a half circle and deposits it in the trench at the rear, after the pipe has been laid, thus putting in the back fill with the one operation. The actual cost of digging the trench by this method is very low, provided the cost of blocking up the shovel is not increased too much by caving in of the sides of the trench.



Giant Class F 45-ton Steam Shovel Digging a Sewer Trench at South Omaha, Neb. National Construction Co., Contractors.



LITTLE GIANT TRENCH SHOVEL DIGGING A SEWER TRENCH 20 FEET DEEP IN ST. LOUIS, MO. THE PIPE LINE WAS 20,000 FEET LONG AND 7 FEET IN DIAMETER. PARKER-WASHINGTON CO., CONTRACTORS.



The Thew Shovel for Sewer Trench Excavation



FRONT VIEW LITTLE GIANT TRENCH SHOVEL.

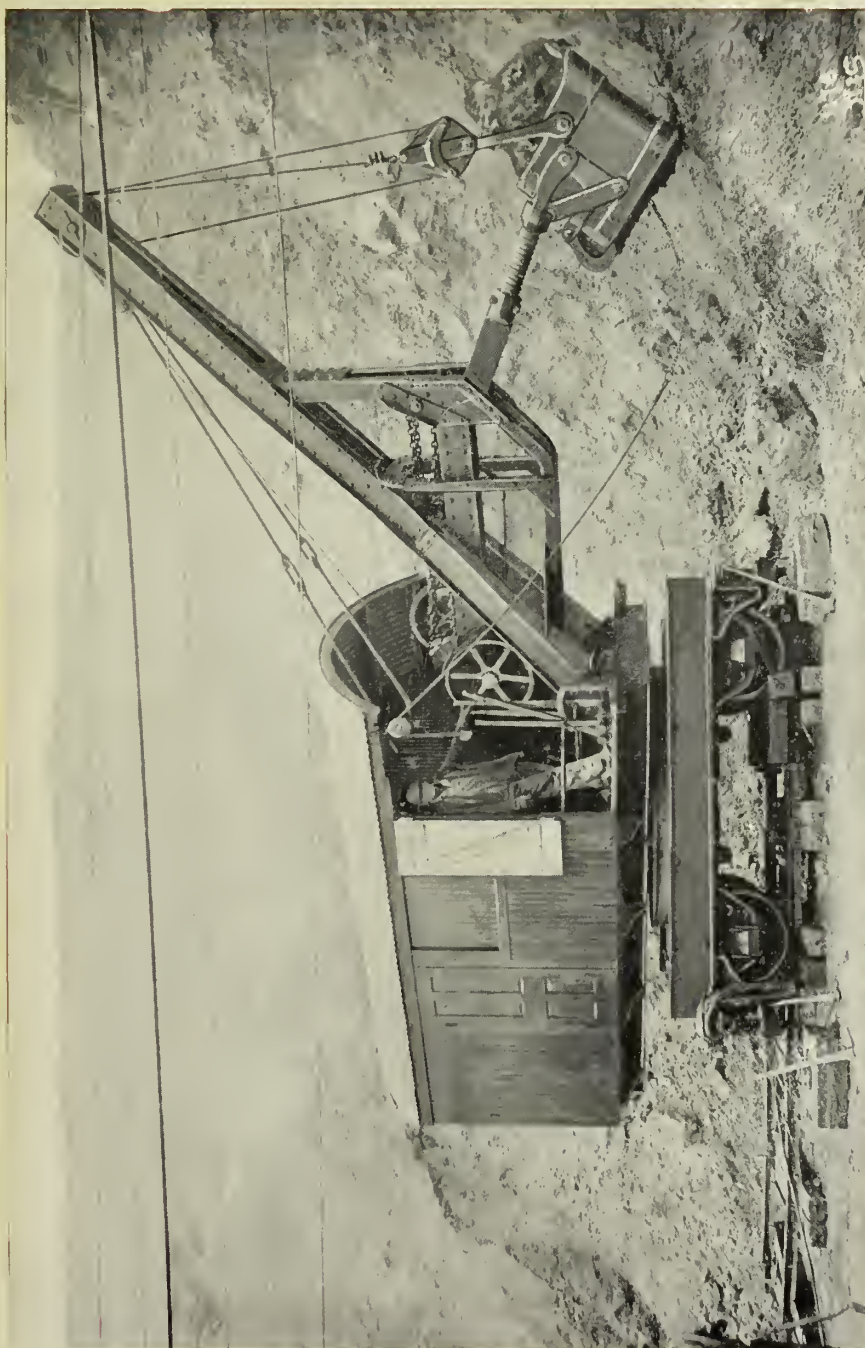
The prices of steam shovels range from about \$4,000.00 to \$10,000.00, or approximately \$130.00 per ton. The depreciation usually amounts to about 9 per cent. Of course, there is a great variation in depreciation owing to the treatment to which the shovel is subjected. Estimating interest at 6 per cent and depreciation at 9 per cent, gives a total of 15 per cent. This is the amount usually considered by contractors.

ELECTRIC SHOVELS. -- It is frequently desirable to make use of power shovels under conditions that preclude the use of steam. Where fuel or water are not available, or for operations in tunnels, underground mines, or confined spaces, it is at times possible to substitute electrical power. For such requirements the engines and boilers of the standard machines are replaced by electric motors of suitable design. Any one of the various forms of electrical current in commercial use can be adapted to service of this nature and any shovel can be equipped for electrical operation. For such installations the motors are especially adapted to the requirements which are both peculiar and severe.

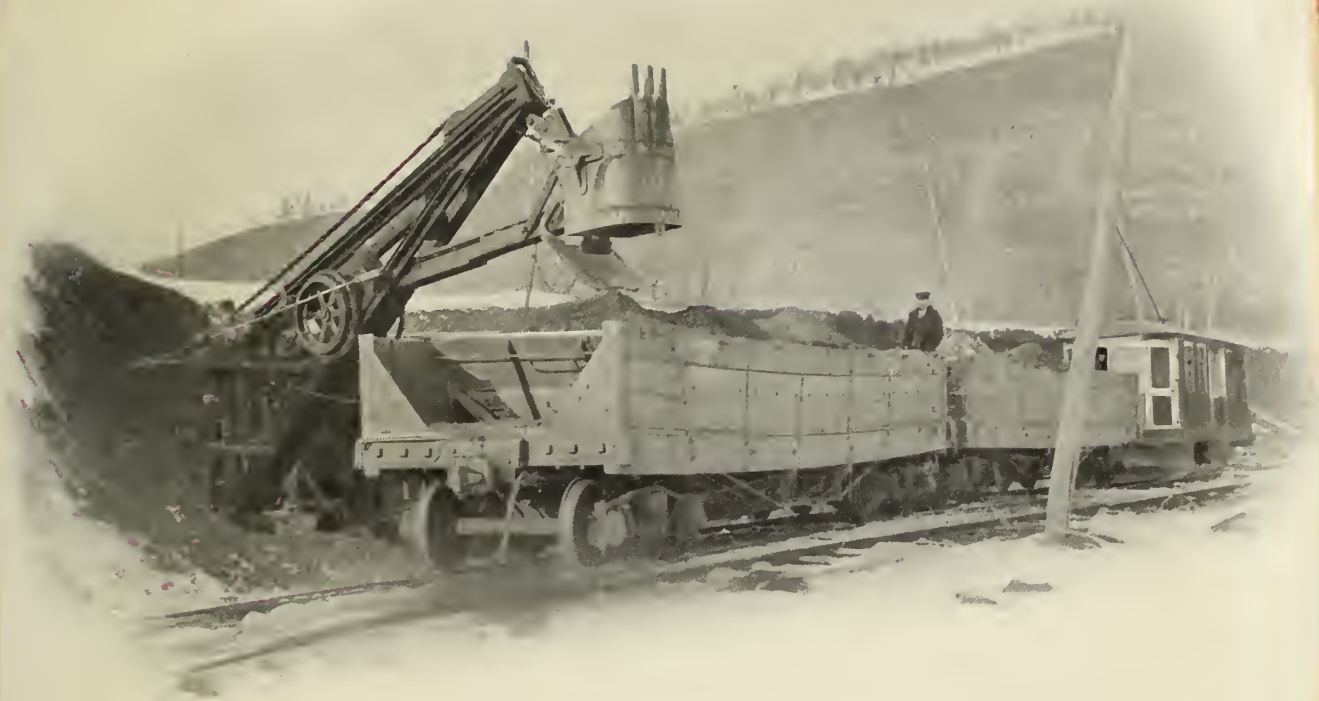
The current is preferably received through contact rings on the truck frame, to which are connected flexible cables from the feed line. These cables are wound around a spool which unwinds as the shovel moves forward. With this arrangement the feed wires do not have to be lengthened every time the machine shifts forward.

Electric shovels work more economically than steam shovels but the original cost is greater due to the high cost of the heavy electric machinery.

These machines are used to great advantage by electric railroads.



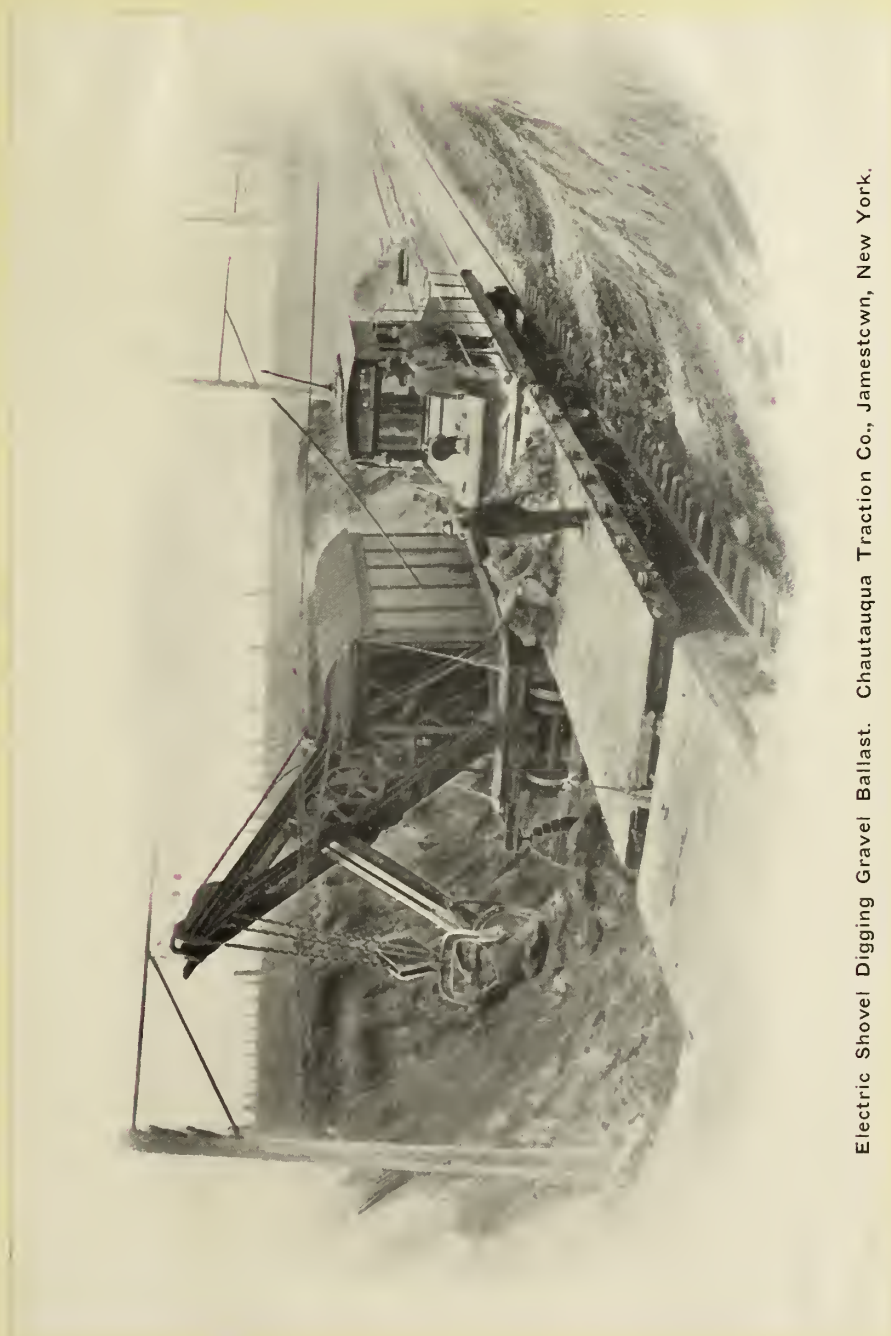
No. 2 Shovel Equipped With Electric Motors



Electric Shovel Loading Into Cars. W., N. Y. & P. T. Co., Olean, New York.



Electric Shovel Digging Gravel Ballast. W., N. Y. & P. T. Co., Olean, New York.



Electric Shovel Digging Gravel Ballast. Chautauqua Traction Co., Jamestown, New York.

EXCAVATORS.

Excavators differ from steam shovels in several ways, viz., (1) shovels act away from their power and machinery while excavators act towards their engines; (2) the dipper on a shovel is held rigidly in the ground by the boom and dipper arm; the bucket on the excavator is loosely suspended from the end of the boom by blocks and cables; (3) shovels travel on the excavated floor; excavators travel on the top of the cut; (4) excavators require a larger gauge track than shovels; (5) excavators are more awkward to move any considerable distance (say 1/2 mile); (6) excavators work slower than shovels.

Hence, it is seen that these two machines are not rivals. The excavator is designed for digging drainage and irrigation ditches, for use in gravel pits, digging cellars, stripping coal, road and street work, and for other similar purposes. This machine will operate in any kind of soil which does not require blasting.. The "cut" at the end of this article shows a Lidgerwood-Crawford Excavator with a Page Scraper Bucket operating in from 6 to 24 inches of frozen "Red Horse".

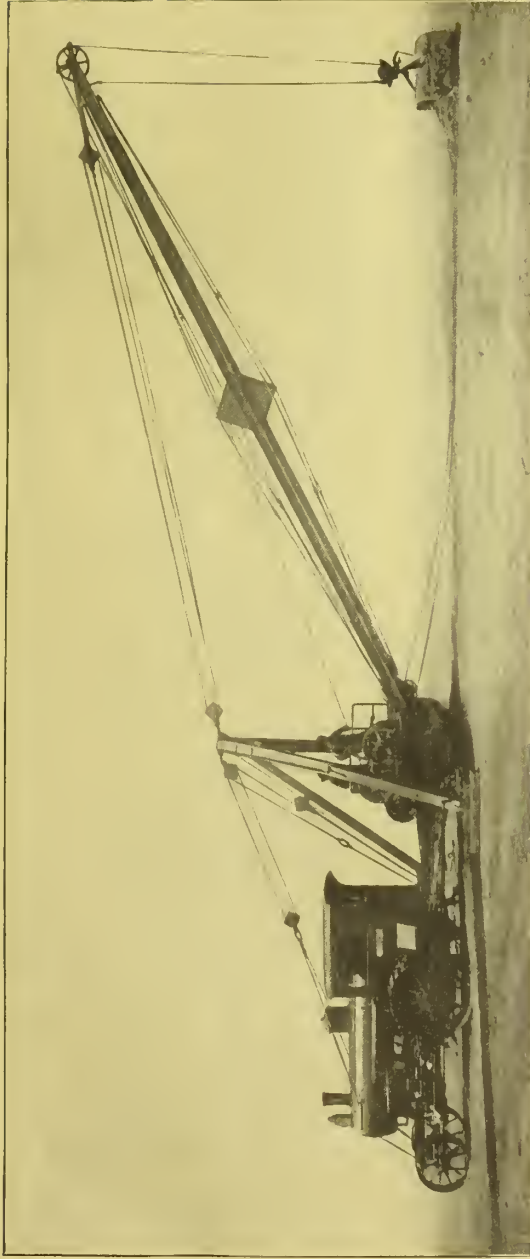
The general operation of an excavator resembles closely that of a revolving steam shovel. The boom and its controlling machinery is located upon a turntable, which consists of two rail circles, one secured to each of the upper and lower frames. The height of the bucket is controlled by the cables running up over the end of the boom. The bucket is filled by winding the cable over a drum and dragging the bucket towards the machine.

The digging or pulling line attached to the bail of the bucket and also to the lower drum of the main engine, after pas-

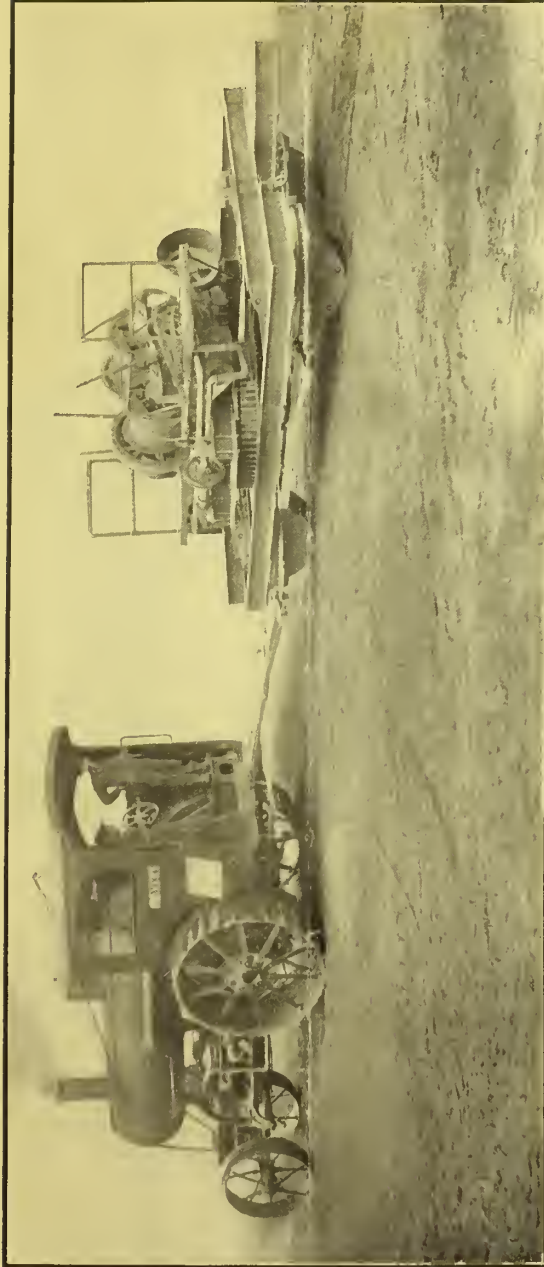
through a padlocked carriage, is drawn towards the machine until the bucket is filled. The foot-brake of the lower drum is then applied, the pneumatic control reversed, and the bucket hoisted by the application of the friction of the upper drum of the main engine, the operator in the meantime paying out on the digging or pulling line by his foot-brake. The pneumatic power to the swinging engine is then applied, the machine is swung to the point of dumping, the foot removed from the brake holding the bucket in a horizontal position, and the bucket then dumps automatically by gravity. The pneumatic power is then applied to the swinging engine again, which turns the upper turntable of the machine to the desired point of digging, the bucket is dropped to the ground and the operation is repeated. This machine shifts its own track sections, thus dispensing with a number of track men.

For continuous work the moving does not count much as it only moves 10 feet at a time, and before it needs moving again it will move from 250 to 300 cu. yds. of earth. Removing the front stop blocks and dropping the bucket into the ground in the direction desired to move, the machine pulls itself forward and is ready for work.

Excavators are operated by two different methods: (1) by using a traction steam or gasoline engine to furnish power; (2) by placing stationary engines upon the turntable, as in revolving shovels. The traction engine is used most advantageously in street or road work, in digging cellars, and where moves are frequent. The Avery Company of Peoria, Illinois, manufacture a machine used with a traction engine, which finds no difficulty in going over country roads.

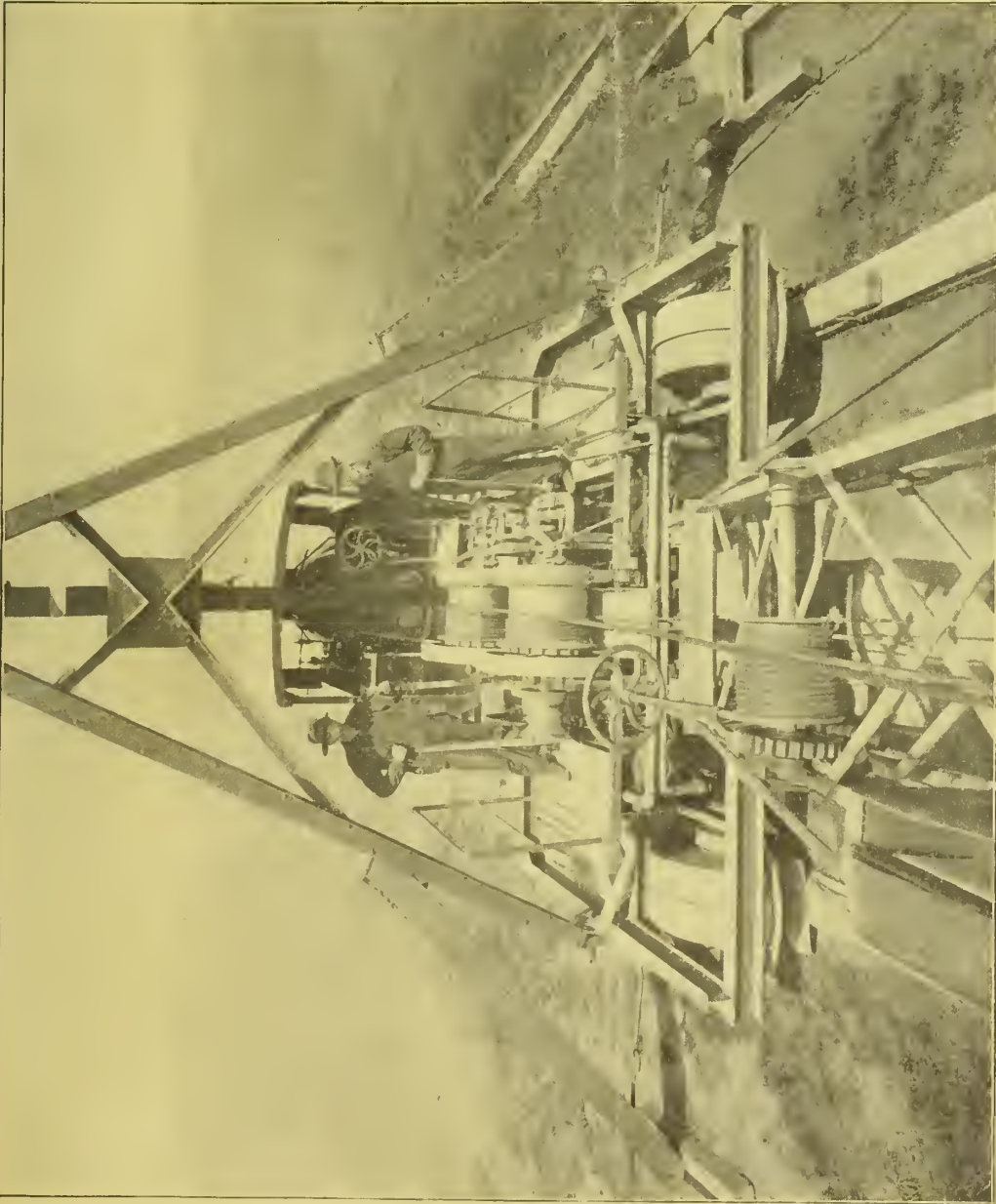


The AVERY TRACTION STEAM SHOVEL
— AND CRANE — 1909 STYLE —



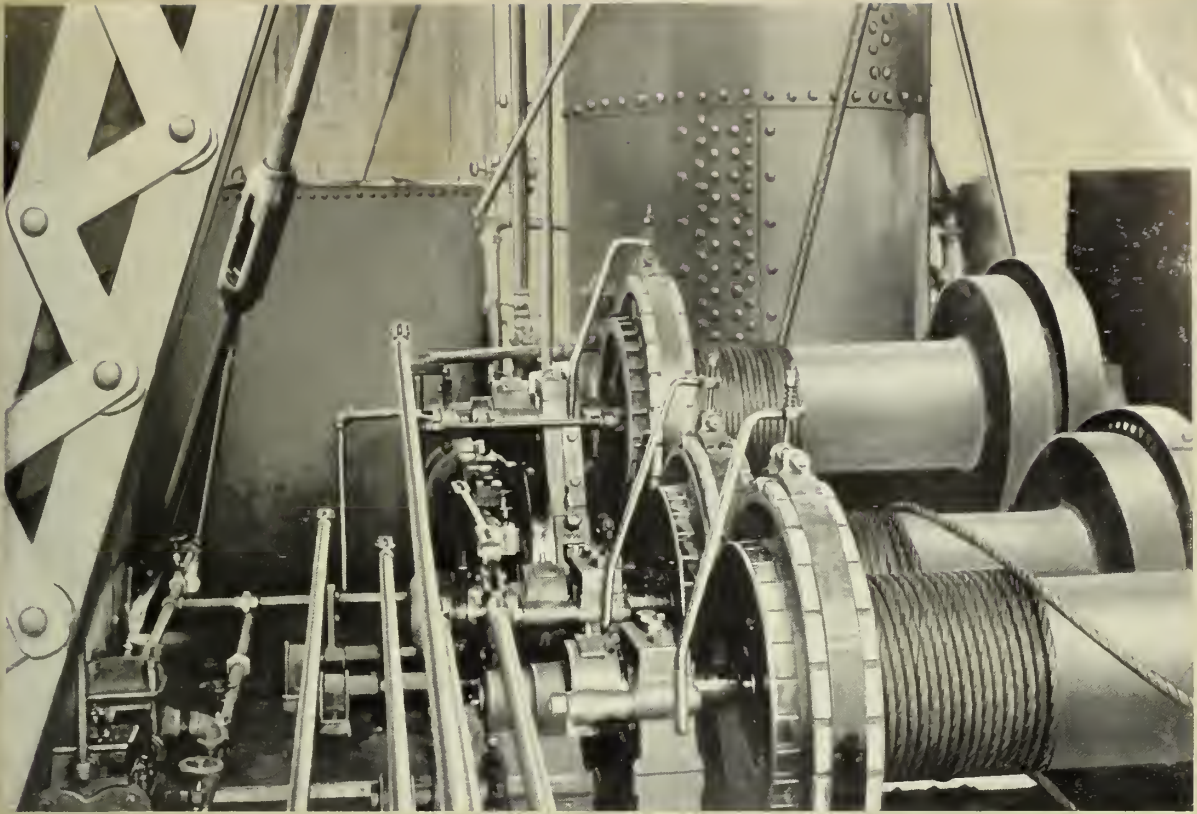
SHOWING SHOVEL MAIN FRAME AS ARRANGED FOR MAKING MOVES

The frame work is so arranged that it can be mounted on a third carrying wheel and pulled from the side in order to travel readily on ordinary roads and to cross bridges.



SHOWING WINDING DRUMS, LEVERS AND POSITIONS OF OPERATORS
(Looking Down from the Boom)

The operator at the right handles the throttle lever and the two levers which operate the friction clutches in the drums; also uses his feet for the drum friction brakes. The operator at the left handles the two levers which operate the device for swinging the boom. The swinging of the boom is effected by a series of gearing, the main feature of which consists of a small bull gear which revolves around a large main gear bolted securely to the main frame work. Hand wheel in foreground is for raising boom.



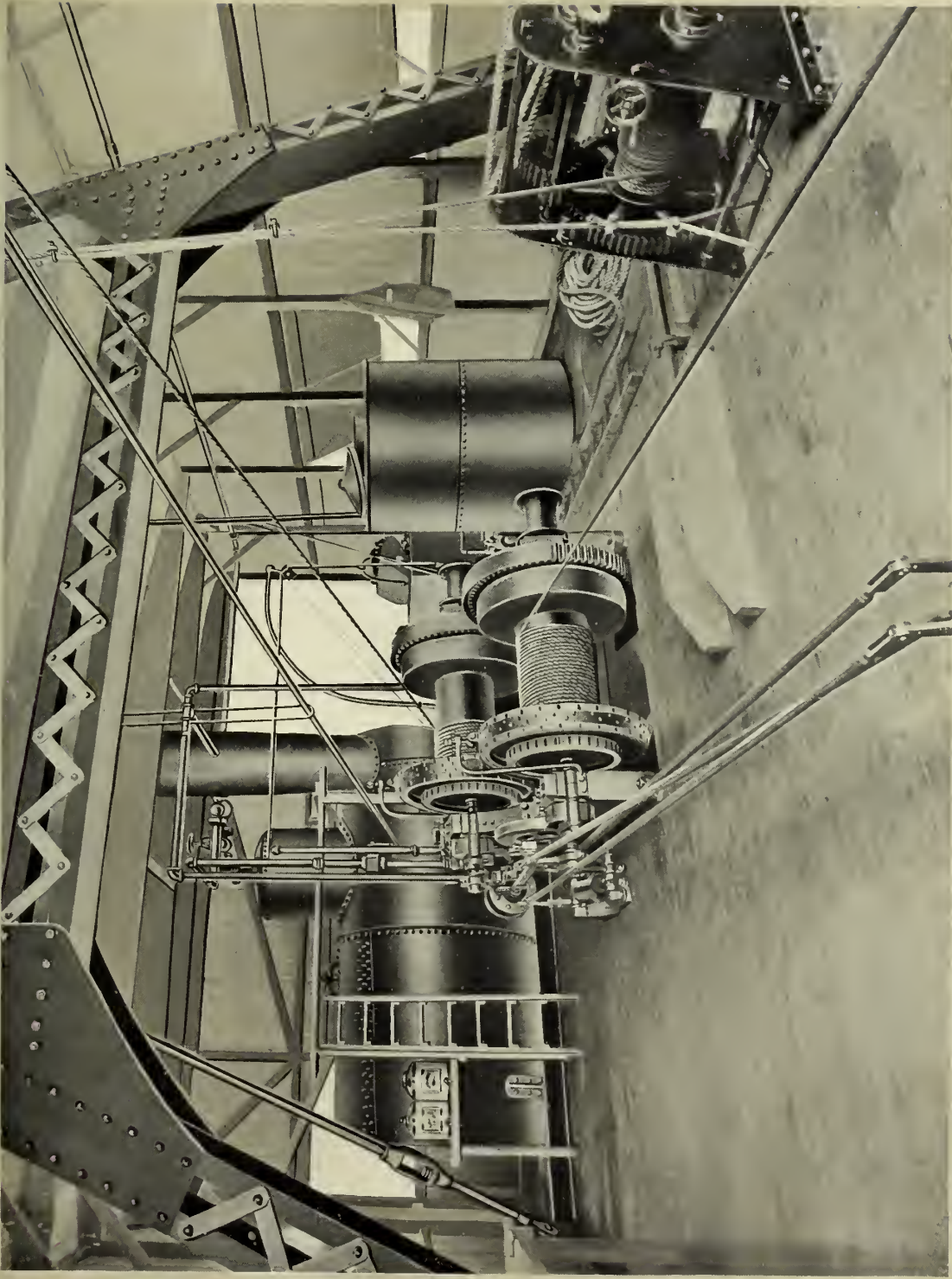
Copyrighted 1909, by Lidgerwood Mfg. Co., Chicago, Ill

"Lidgerwood-Crawford Class B Scraper Bucket Excavator." Interior of engine house on Excavator, showing special three-drum outfit, the third drum used for "topping" the boom.



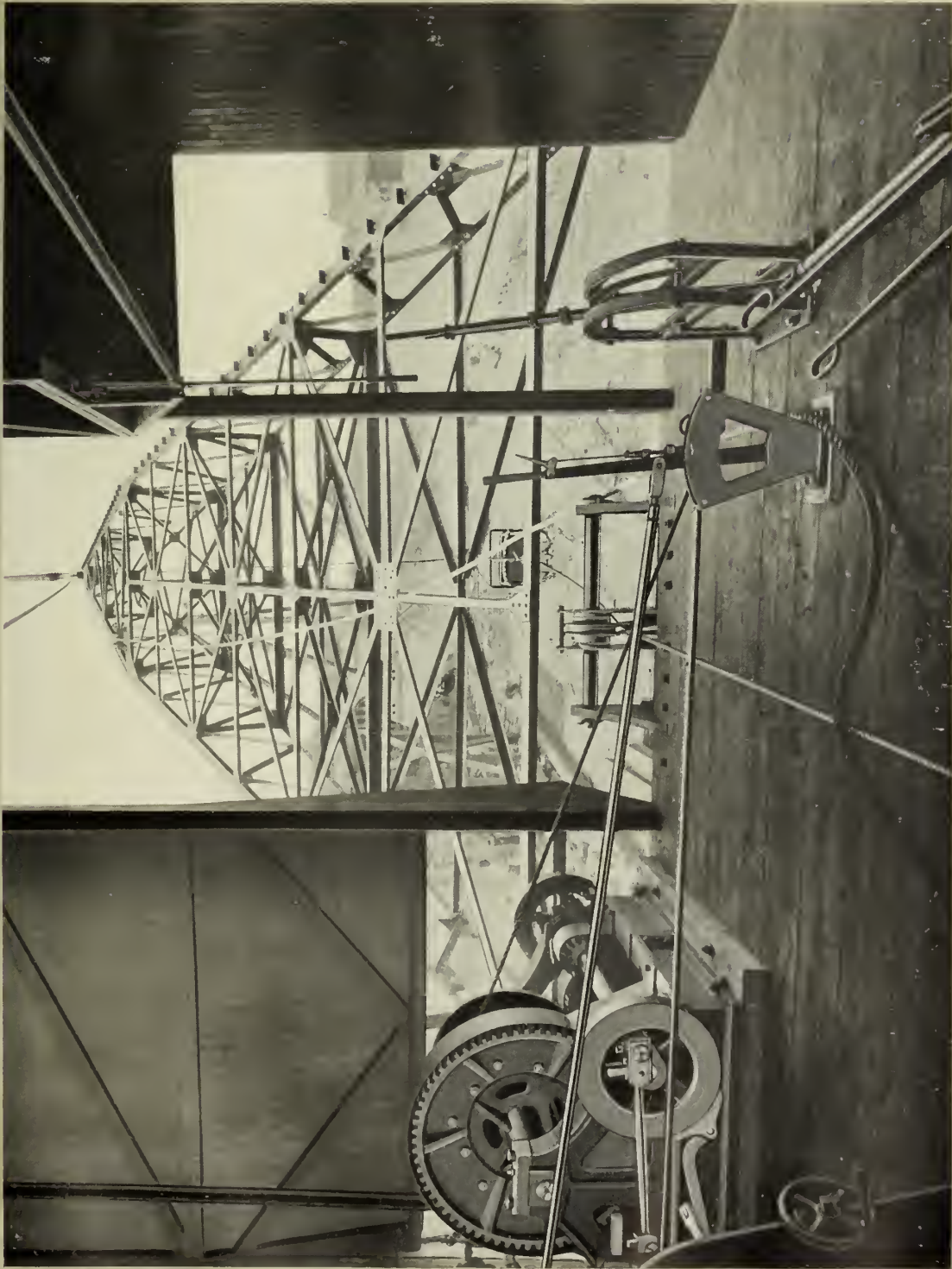
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"Lidgerwood-Crawford Class B Scraper Bucket Excavator" engine set up complete, preparatory to loading on barge for transportation up Mississippi River to destination.



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"Lidgerwood-Crawford Class C Scraper Bucket Excavator," showing interior arrangement—
boiler, main engine, water tank, coal hoist, duplex pump and boom winch.



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"Lidgerwood-Crawford Class C Scraper Bucket Excavator," looking out to end of boom; also showing the "padlock" carriage, swinging engine and operating levers.



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"Lidgerwood-Crawford Class C Scraper Bucket Excavator," handling one of the 15-ft. sections of its own track.



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"Page" Scraper Bucket with Teeth.

The drag line scraper buckets used on the various types of excavators differ only in detail. The Page Scraper Bucket is a good example of this type and the preceding cut shows the construction. These buckets are built in the following sizes:

	$\frac{3}{4}$	cu. yd.	
	1	"	"
1	$\frac{1}{2}$	"	"
	2	"	"
2	$\frac{1}{2}$	"	"

The use of the 2 $\frac{1}{2}$ yd. bucket is not recommended, as a smaller bucket can be handled much more rapidly, with better results at a less expense of power.

The price of excavators ranges from \$6,000. to \$9,000. an 80-ton machine costing \$8,500. f.o.b. at the factory. To this cost, from \$800. to \$1,000. should be added as the cost of erection.

Using a 2 1/2 yd. bucket, the cost of operating an 80-ton machine is as follows:-

	Per 10-hr. Day.
1 operator, at 50¢ pr.hr.	5.00
1 fireman, at 20¢ " "	2.00
1 man and team to haul coal and water at 40¢ per hour, ...	4.00
2 track men at 15¢ pr. hr.	3.00
15 per cent on \$10,000. plant at \$4.00 distributed over 150 days worked per year, ...	<u>10.00</u>
Total per 10-hr. day.	29.30

This machine can easily average 2 cu. yds. per minute and will be in operation at least 0.6 of the 10-hr. day. This would give a cost of approximately 4 cts. per cu. yd!

The cost of stripping coal at Tofield, Alberta, Canada, with an 80-ton Lidgerwood-Crawford Excavator and a 1 1/2 yd. Page Scraper Bucket gave a cost of slightly over 5 cts. per cu. yd.

The bucket may be detached and the excavator used as a locomotive crane and where conditions are unfavorable the drag line bucket may be replaced by either an orange-peel or a clam-shell bucket.

Two Lidgerwood-Crawford scraper bucket excavators, weighing 40 tons each, were used on contract 61 of the New York

Barge Canal. Contract 61 lies in the neighborhood of Brockport, on the 60 mile level between Rochester and Lockport.

One operator, one fireman, and three men to shift and level up the track were needed for each machine.

The excavators were operated entirely on the banks, opposite each other, one on each side of the canal, even after the canal prism was drained at the close of navigation.

The average excavation per station was 2000 yds. for the whole length of the contract. The machine took out about 90 per cent of the total excavation, leaving 10 per cent to be trimmed by hand.

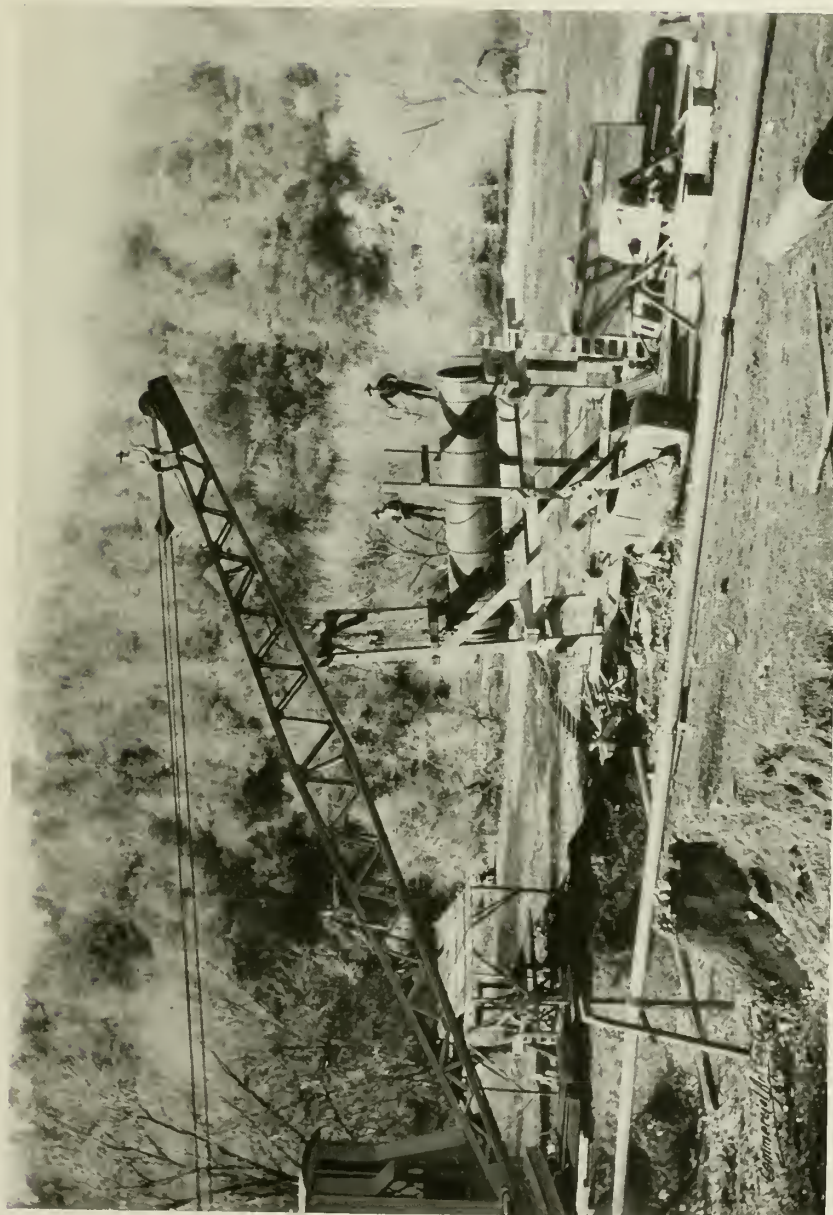
On part of this work it was necessary for one machine to rehandle the spoil excavated by the other. In such places the yardage to be removed from one side of the canal was not sufficient for the embankment on that side, and consequently earth taken from place by the machine on the opposite bank was thrown in the center of the canal in order that the other machine could pick it up.

The following details from the excavation records indicate the amount of work that can be expected from machines of this size and type. The work previous to November 15 was really dredging, since the water was still in the canal and navigation was in progress. After that date the canal was drained, though sufficient water was allowed to remain in the bed to give material for wet embankment. Reference is made to the excavators by number, and a day is here taken to mean a single 8-hour shift.

WORK OF 1 1/2 YD. SCRAPER BUCKET EXCAVATORS.

Month.	Machine.	Days worked.	Distance moved.ft.	Cu.yd. moved.
August.....	No.1	26	500	7277
September...	No.1	25	650	9580
September...	No.2	25	750	5422
October.....	No.1	24	650	8620
November....	No.1	24	500	6280
December....	No.1	24	575	5782
December....	No.2	24	500	4921
January.....	No.1	23	1100	3070
January.....	No.2	22	700	3296

Of the two machines No. 2 worked constantly at a disadvantage, for the material handled by it went into embankment, where bad material could not be deposited and rocks had to be removed. No. 1, on the other hand, spoiled most of its material, and threw the remainder to the center of the bed of the canal, whence it was rehandled by the other machine. The records for No.2 are not given in the table for all months. This is due to difficulty in estimating the quantity of rehandled material. In November, for example, most of the work of No. 2 consisted in rehandling and the total output of the two machines, excavation paid for only once, was 10,272 cu. yd. for the 24 working days. No record was kept of the amount spoiled directly by No. 1 and of the remaining yardage rehandled by No. 2



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Class "B," "Lidgerwood-Crawford" Excavator, used as a derrick in the erection of
a Gold Washing Plant for Placer Mining, near San Andreas, Cal.



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"Lidgerwood-Crawford Class A Scraper Bucket Excavator," patented, digging a waterway.



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"Lidgerwood-Crawford Class A Scraper Bucket Excavator." One of two Class A excavators on Northern Pacific Ry. construction work at Woodland, Washington.



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"Lidgerwood-Crawford Class A Scraper Bucket Excavator," cutting waterway through a cypress swamp at Gentilly, Louisiana.



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Class "C," "Lidgerwood-Crawford" Excavator, with 100 foot boom and 62 cubic foot "Page" Scraper Bucket, working in from 6 inches to 24 inches of frozen "Red Horse" on the "State Barge Canal," near "Eagle Harbor," N. Y.



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Class "C," "Lidgerwood-Crawford" Excavator, with 80 to 100 foot boom and 62 cubic foot "Page" Scraper Bucket, working in from 6 inches to 24 inches of frozen "Red Horse" on the "State Barge Canal," near Knowlesville, N. Y.



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Class "C," "Lidgerwood-Crawford" Excavator, with 100 foot boom and 62 cubic foot "Page" Scraper Bucket, working in from 6 inches to 24 inches of frozen "Red Horse" on the "State Barge Canal," near "Eagle Harbor," N. Y.



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A Class B "Lidgerwood-Crawford" Excavator, mounted on a barge, digging in water and building a levee along the Mississippi River.



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A Class B "Lidgerwood-Crawford" Excavator, mounted on a barge, digging in water.



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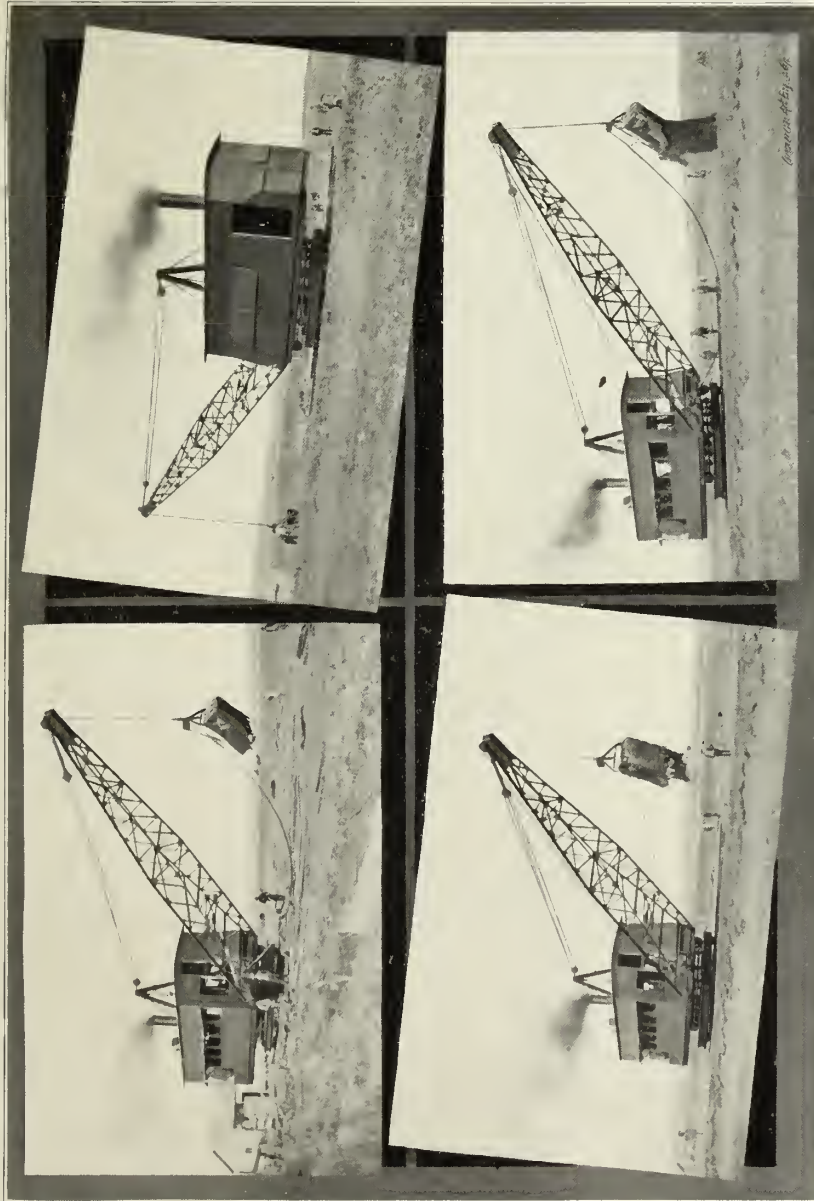
"Lidgerwood Crawford" Excavator with "Page" Scraper Bucket, in Placer Mining Work on
Property "Orsk Goldfields, Ltd.," Eastern Siberia



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Class "B," "Lidgerwood-Crawford" Excavator, with 60 foot boom and one-half yard "Page" Scraper Bucket, on Placer Mining work, near San Andreas, Cal.

Commercial Art Photo Co.



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The "Lidgerwood Crawford" Excavator with "Page" Scraper Bucket, Digging Canals for Rice Irrigation in Louisiana on Property The United Irrigation & Rice Milling Co.

SKID EXCAVATORS. - The hoisting engine and machinery and the boom of a Skid Excavator is mounted upon a heavy timber frame work which moves by sliding along on skids. This machine may be placed upon a flat car, and transported from place to place and used as a travelling excavator, without being knocked from the car.

The Skid Excavator differs from the Locomotive Crane in that the main body is stationary, thus only permitting the boom to swing through an arc of 180° .

The first cost and cost of operation of this machine is practically the same as that of a locomotive crane.



This Skid Excavator was used for digging lock foundations on the Hennepin Canal. The material was sand, clay and gravel.



Owing to the width of the Hennepin Canal on which the Skid Excavators, shown above, were operated, two machines with 90 foot booms were used.



Showing one of the excavators and the land through which the canal was dug. After clearing the ground some of the larger stumps were blasted while the smaller ones were removed by the bucket without blasting.



This illustration shows about 600 feet of the finished canal, into which the water has been allowed to run. In the distance can be seen the excavators which operate 1 1/4 cu. yd. orange peel buckets.



Skid Excavators were used for straightening the Mohawk River at Utica, N.Y. The machine shown above operates an orange peel bucket.



This illustration shows the Hayward Orange Peel Bucket in the Excavation, and gives a much better idea of the material handled.



A one cubic yard Skid Excavator is shown above, the Orange Peel Bucket as well as the machine is operated by a standard contractor's engine.



The illustration shows a small sized Skid Excavator used at Cape Nome, Alaska, for digging gold bearing soil.

THE TRAVELLING DERRICK or RAILROAD EXCAVATOR. - This machine is the same as the skid excavator, only the travelling derrick is mounted on trucks of either standard or wide track.

The following cuts taken on the Hennepin Canal, Mohawk River, U. S. Reclamation Service, and the Erie Canal, give a good idea of the operation of the Travelling Derrick and the Skid Excavator.

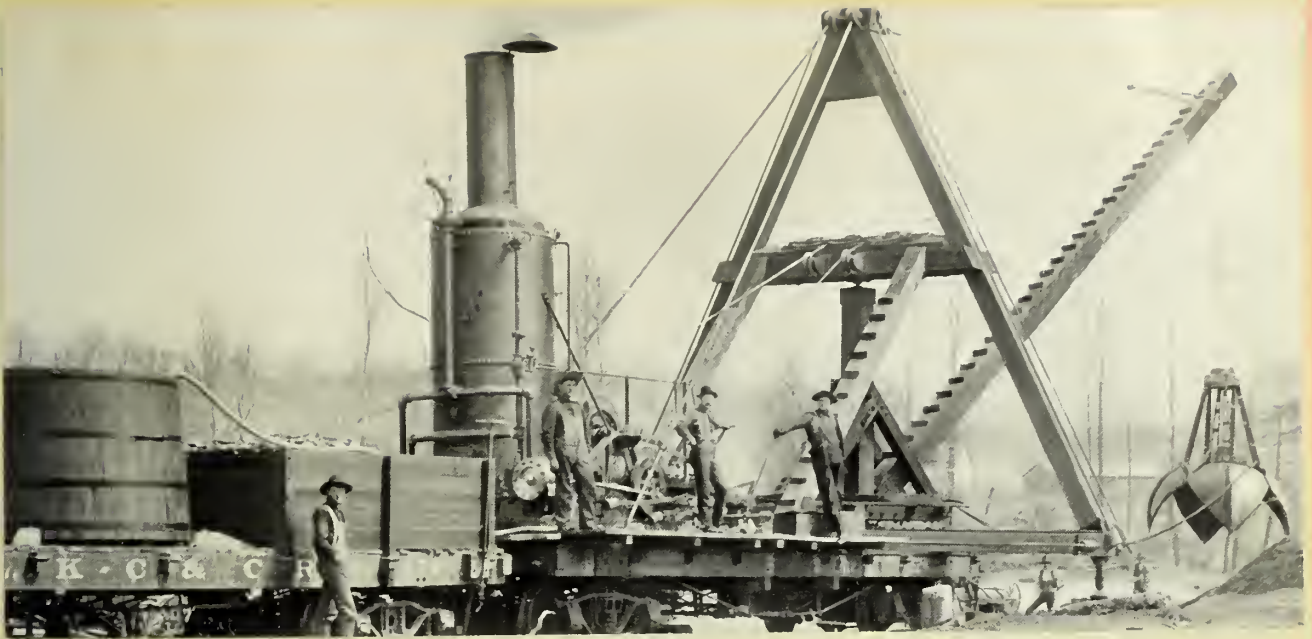
Both machines use the orange-peel or clam shell buckets.



The travelling derrick shown above was used on the Erie Canal.



The machine shown is a travelling excavator which may be used as a derrick when not operating the bucket.



A machine which may be mounted on an ordinary flat car is shown above. The boom is stationary but can be fitted with a variable lift when required. A standard contractor's engine is used for operating the bucket.



One of the ten Railroad Excavators furnished the Florida East Coast Railroad. Gas engines are used for operating the Hayward Orange Peel Buckets, employed in making railroad embankments along the line of their railway.

LOCOMOTIVE CRANE. A locomotive crane closely resembles a steam shovel. In fact, most steam shovels or excavators may be used as a locomotive crane when a longer and lighter boom is substituted for the standard boom, and auxiliary mechanism is added to secure the usual derricking motion for varying the radius of the boom.

An orange-peel or a clam shell bucket is always used in connection with the locomotive crane on earthwork. A locomotive crane, so equipped, will work in average earth, this being anything that can be plowed with a two horse team.

This machine is made to run on a standard gauge track and is also furnished with wide tires so that it can be run on the ground.

A locomotive crane can be operated at a lower cost than either the steam shovel or excavator as it would not require a fireman and probably not the two laborers who act as "flunkies".

An orange-peel or a clam shell bucket would not average more than one half full, but an ordinarily skillful operator would probably make two trips per minute, thus giving a theoretical hourly capacity of 60 cu. yds. with a 1 yd. bucket. The crane, owing to delays in moving up to the work, waiting for cars or wagons, etc., would not actually work more than 7 hours, so if 10 yds. is deducted from the theoretical hourly capacity, to take care of unforeseen delays, the daily capacity would be 350 cu. yds. per 10-hr. day.

Cranes cost approximately the same as steam shovels, from \$4,000. to \$9,000.

Considering one costing \$6,000. the daily cost of operation would be:

1 engineer, ... \$3.50

1 man and team hauling
fuel and water, . . . 4.00

Fuel, 3/4 ton, . . . 1.50

Oil, waste, etc., ...50

Repairs, depreciation,
and interest, 15 p.ct. 6.00

Total, per 10-hr. day, \$15.50

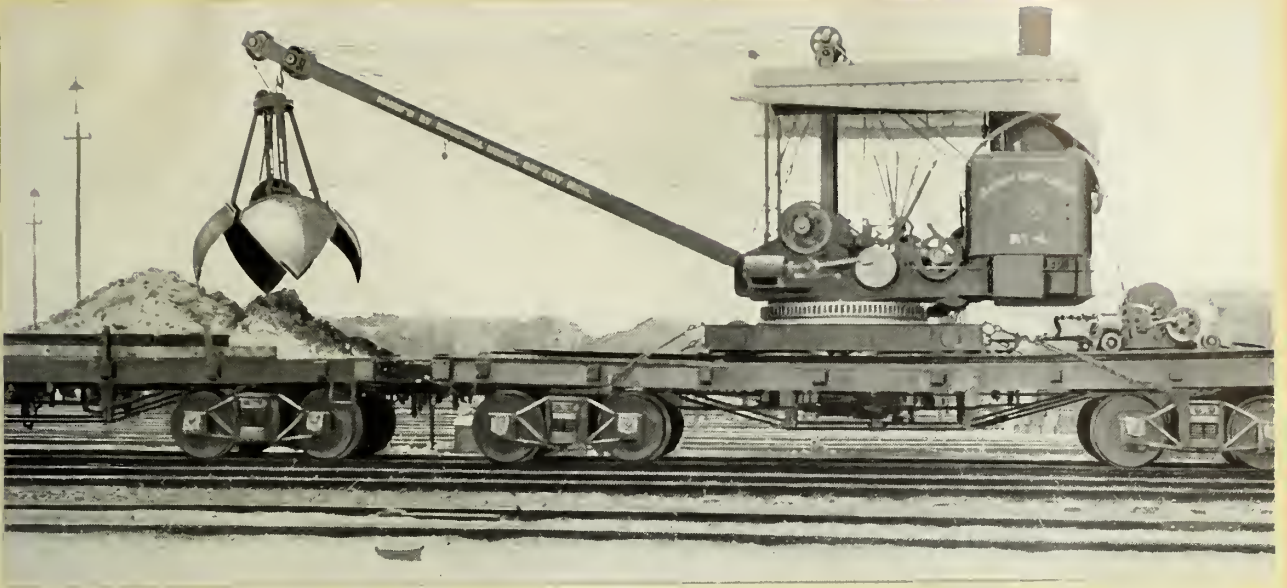
This gives a cost of nearly 5 cts. per cu. yd. with a very limited output.



No. 1 LOCOMOTIVE CRANE BUILT FOR EITHER CLAM SHELL BUCKET
OR DIPPER AND DIPPER HANDLE.



No. 1 ELECTRIC LOCOMOTIVE CRANE EQUIPPED WITH CLAM SHELL BUCKET



A crane mounted on a flat car and propelled forward and backward by a small engine is shown above. A machine of this description was used on the extension of the Florida East Coast Railway.



Coraline rock was used for ballasting portions of the Florida East Coast Railway. After blasting it was loaded into cars with an orange-peel bucket operated by a locomotive crane.



Browning Locomotive Crane for sewer and other excavating.



Browning Locomotive Crane with Grab Bucket for digging sand and gravel.

BUCKETS.

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ORANGE PEEL BUCKET. - The orange-peel bucket consists of a frame from which are suspended a number of spherical triangular spades which are forced vertically into the ground by their own weight. The pull upon the bucket to lift it out of the ground draws these triangles together and incloses the earth to be excavated. These buckets are constructed with three or more curved triangular blades and when closed form a tight semi-spherical bowl. Either wire rope or chain is used in operating the bucket.

This bucket will work in any earth that can be plowed with a two-horse plow. It is used in connection with the locomotive crane, the skid excavator, travelling derrick, and with dredges.

STANDARD ORANGE PEEL BUCKETS. - This type of bucket is adapted to all classes of dredging and excavating, and is also used in the West for handling run of mine coal from barges.

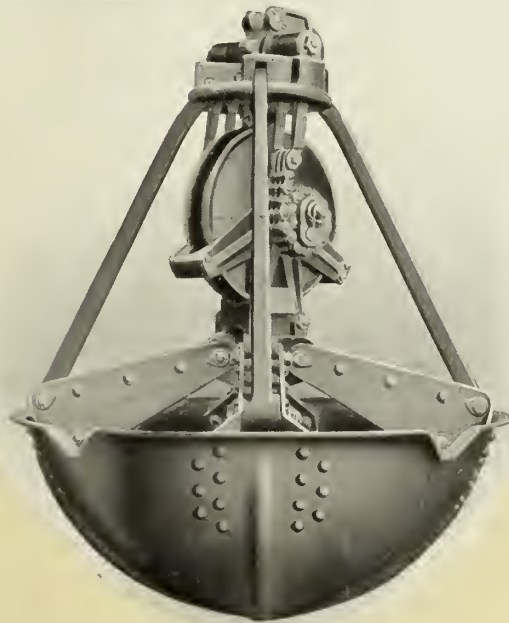
The blade arms, connecting the blades to the lower center casting, are straight, thus allowing a greater amount of clearance in the bowl when the bucket is closing and closed.

Outside shaft bearings are used on buckets of 21 cu. ft. capacity and larger.

Capacity.	Approximate weight in Pounds.	Closed		Net Price.
		Diameter ft.in.	Height ft.in.	
1 Cubic Foot	125	1 9	2 6	113.75
2 1/2 Cubic Feet	450	2 6	3 9	162.50
5 Cubic Feet	900	3 2	4 9	292.50
7 Cubic Feet	1000	3 6	5 0	308.75
9 Cubic Feet	1100	3 10	5 2	325.00
12 Cubic Feet	2150	4 3	6 4	471.25
15 Cubic Feet	3750	5 0	7 9	650.00
1 Cubic Yard	4200	5 8	8 0	682.50
1 1/4 Cubic Yards	4750	6 0	8 3	780.00
1 1/2 Cubic Yards	5250	6 4	8 8	877.50
1 1/2 Cubic Yards	7750	6 4	9 6	1040.00
2 Cubic Yards	8500	7 8	10 0	1137.50
2 1/2 Cubic Yards	9500	7 8	10 4	1267.50
3 Cubic Yards	10000	8 0	10 8	1397.50



Standard Orange Peel Buckets



MULTI-POWER ORANGE PEEL BUCKETS.- For digging clay, compact sand, and other hard materials the Multi-Power Bucket has no equal. It is built along the same general lines as the Standard, but differs in the closing mechanism, which, in this case, is multiplied, giving twice the closing power with but half the uplifting tendency when closing.

Outside shaft bearings fitted with bronze bushings, are used on all sizes. It is also fitted with outside points, which give the blades a smooth surface on the inside. This is of great advantage when handling sticky materials.

This type of bucket can be operated by wire rope only.

Capacity.	Approximate weight in pounds.	Closed.		Net Price.
		Diameter.	Height.	
		ft.in.	ft.in.	
21 Cubic Feet	4200	5 0	7 11	715.00
1 Cubic Yard	4750	5 8	8 2	828.75
1 1/4 Cubic Yards	5350	6 0	8 6	942.50
1 1/2 Cubic Yards	6000	6 4	8 8	1040.00
1 1/2 Cubic Yards	8500	6 4	9 10	1300.00
2 Cubic Yards	9500	7 0	10 4	1462.50
2 1/2 Cubic Yards	10500	7 8	10 8	1625.00

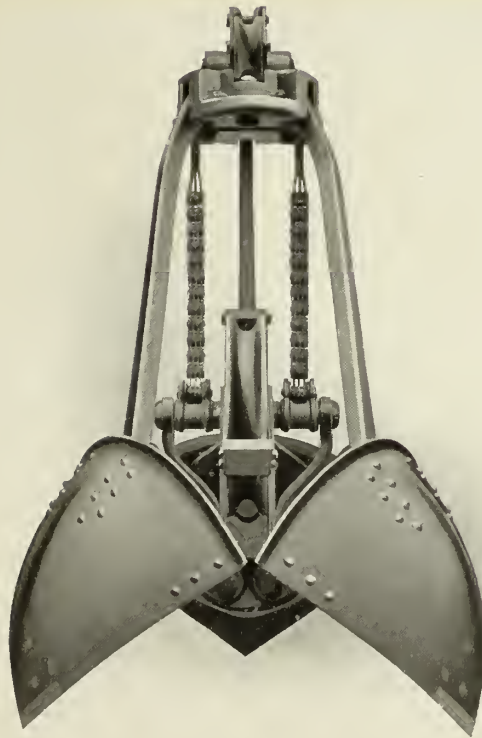


Multi-Power Orange Peel Buckets

THE THREE-SIDED ORANGE PEEL BUCKET. - A style of bucket especially well adapted for the handling of boulders, broken rock, and other odd-shaped material which present uneven surfaces and are difficult to hold unless an even force is exerted on each bearing part.

The three blade points of this style of bucket, coming in contact with a boulder, will either force it inside the bowl, or will grasp the object in such a manner that the holding force will be positive and the strain will be equally divided throughout the entire bucket.

Capacity.	Approximate	Closed		Net
		Diameter.	Height.	
		ft.in.	ft.in.	Price.
21 Cubic Feet	4200	5 0	7 11	715.00
1 Cubic Yard	4750	5 8	8 2	828.75
1 1/4 Cubic Yards	5500	6 0	8 6	942.50
1 1/2 Cubic Yards	8500	6 4	9 10	1300.00
2 Cubic Yards	9500	7 0	10 4	1462.50
2 1/2 Cubic Yards	10500	7 8	10 8	1625.00



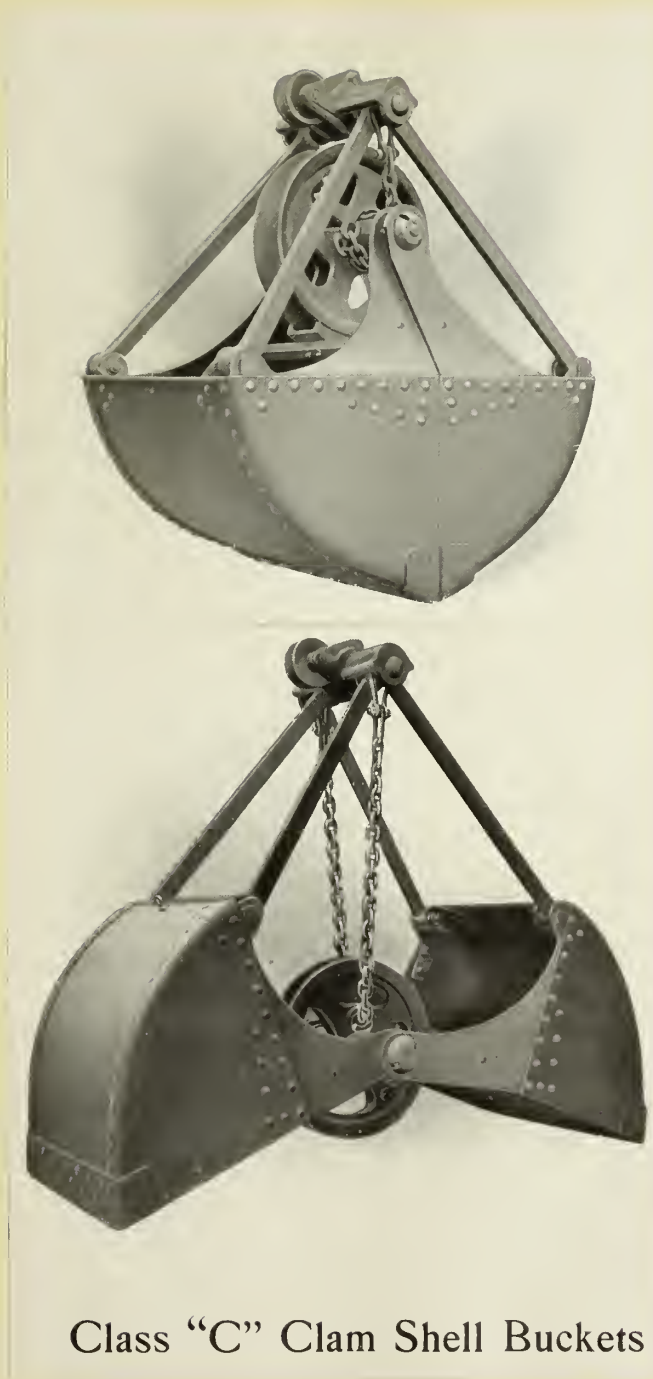
“Three-Sided” Orange Peel Buckets

CLAM SHELL BUCKETS. - The clam shell bucket consists of the two halves of a hemispherical shell, which rotates about a horizontal diameter. Vertical arms are riveted on either side of the bowls, and their upper ends are connected to the main shaft on which the power wheel for closing the bucket is located. The edges of the shell or bowl are forced into the soil by the weight of the bucket itself, and the pull upon the chain or cable to raise the bucket draws the two halves together, thus forming a semicylindrical bowl which encloses the material to be excavated.

This bucket is used to the greatest advantage in sandy or very loose earth as it will not fill where the ground is hard.

Clam shell buckets of Class "C" type are used for handling all classes of loose earth.

Capacity :	Approximate :	Width :	Height :	Length :	Net Price. :
Cubic :	Weight in :	Ft.In. :	Ft.In. :	Ft.In. :	
Yards. :	Pounds. :				
1/2 :	2000 :	3 3 :	5 9 :	5 7 :	\$ 357.50 :
3/4 :	2150 :	3 3 :	6 9 :	6 10 :	422.50 :
1 :	2350 :	3 3 :	7 6 :	7 6 :	487.50 :
1 1/2 :	3400 :	3 9 :	8 4 :	8 6 :	552.50 :
1 5/8 :	3500 :	4 0 :	8 4 :	8 6 :	585.00 :
2 :	4500 :	5 0 :	8 4 :	8 6 :	747.50 :
2 1/2 :	5500 :	5 0 :	9 6 :	9 9 :	893.75 :
3 :	6250 :	6 0 :	9 6 :	9 9 :	1056.25 :
4 :	8500 :	6 0 :	10 6 :	11 0 :	1397.50 :
5 :	10000 :	7 0 :	11 0 :	11 0 :	1560.00 :



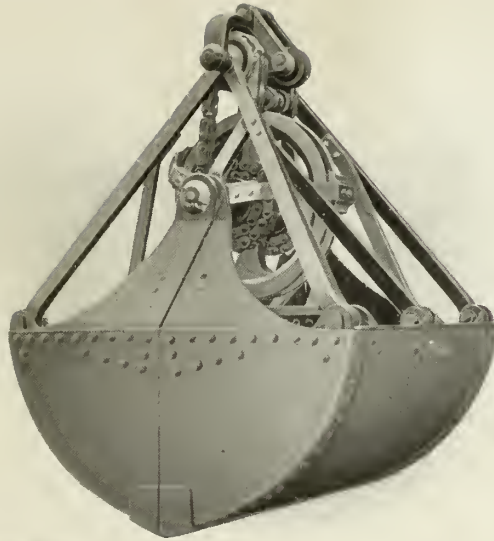
Class "C" Clam Shell Buckets

CLASS "H" - CLAM SHELL BUCKETS. - This type of bucket is designed to handle heavier and rougher materials than the Class "C" type.

Flat link side chains are used and by leading them over sheaves in the head of the bucket, as shown, the closing power is materially increased.

All Class "H" Bowls have plate shoes extending from top of bowl, same as Class "E".

Capacity Cubic Yards.	Approximate weight in Pounds.	Width. Ft.In.	Height. Ft.In.	Length. Ft.In.	Net Price.
1 1/2	4000	3 9	8 9	8 6	715.00
1 5/8	4200	4 0	8 9	8 6	812.50
2	5200	5 0	8 9	8 6	975.00
2 1/2	6000	5 0	10 0	9 9	1153.75
3	6700	6 0	10 0	9 9	1365.00
4	9200	6 0	11 6	11 0	1690.00
5	11500	7 0	11 9	11 0	1950.00



Class "H" Clam Shell Buckets

TRENCHING MACHINES.

- - - - : - - - -

At the present time there are numerous trench excavating machines on the market, which are giving good service. Among which, the ones best known are the Parsons, the Buckeye, the Chicago Ditching Machine, The Austin Wheel Ditcher and the Carson Trench Machine.

In general the operation of all these machines is very similar. The digger consists of either a hollow circular wheel or an excavating beam with a sprocket wheel on either end around which an endless chain of buckets or cups travel. The digging wheel or beam can be adjusted to excavate at any desired depth up to the capacity of the machine.

The power for operating the machine is furnished by either a steam or a gasoline engine mounted upon trucks. These machines are equipped with either a truck mounted on traction wheels, or with a multipedal traction, which enables them to travel over boggy or wet ground that would be impossible for the traction wheel style of truck.

Sizes of trenching machines are given by the width of the cut in inches. Drainage ditch trenching machines are made in sizes varying from 11 1/2 in. x 4 1/2 ft. up to 54 in. x 7 1/2 ft. Sewer ditch trenching machines are made in sizes varying from 20 in. x 5 1/2 ft. up to 78 in. x 25 ft.

Trench excavators will work in any kind of soil, no matter how hard or sticky, that can be plowed or picked. They will not work in quicksand or where there are many boulders,

large roots, or pipes. These machines will take out boulders the size of the buckets or even larger. If it strikes a boulder or a pipe the carrier can be raised automatically by the machine and the earth in front of the obstruction removed.

When the excavator is at work it occupies a space of 8 or 10 feet at the top and $2\frac{1}{2}$ or 3 feet at the bottom; the rear of the excavator is practically in a vertical position and the pipe can be laid up to within 4 or 5 feet of the face of the ditch at all times. When excavating the face or end of the ditch is sloping. At twenty feet deep the excavator has a slope of four feet in twenty feet. When digging twelve feet deep the face of the ditch has practically the same slope and this space, as mentioned before, 8 to 10 on top and $2\frac{1}{3}$ or 3 at the bottom is all the space that cannot be protected by timbering at all times, as this space is occupied by the excavator. The bottom of the ditch requires very little dressing in preparation to laying the tile or pipe.

The weight of the machine is at all times well in advance of the face of the cut; while digging the two rear wheels support the racks that are used in raising or lowering the excavator, the greater part of the weight being distributed ahead of the cut, consequently the compactness and solidity of the soil is undisturbed.

The following table, based on easy spading earth, and assuming that the men digging can excavate and throw back 10 yds. of earth per day, gives a comparison between hand and machine labor in depp trench digging. Wages are \$1.50 per day of 10 hours. The bottom man raises the material to the first

bench, and scaffolds are 4 feet apart to the top. On the top is a bankman to throw the earth back.

Depth of trench in feet,,	8	12	16	20
No. of lifts,	1 1/2	2 1/2	3 1/2	4 1/2
No. of men,	2	3	4	5
Daily average no. cu.yds. per man,	5.7	4.4	3.3	2.5
Cost per cu. yd.	26¢	36¢	45¢	60¢
Cost per lineal ft. of trench, 27" wide,	18¢	34¢	60¢	1.08
100 men would excavate per day - Cu. yds.	570	440	330	250
100 men would excavate per day - Lin. ft.	805	440	247	150

Using a large sized machine in a trench 27" wide for a day of ten hours, the cost varies from 8 to 20 ft. in depth per lineal foot as follows:

Yards Output.	Width.	Depth. Ft.	Cost. cts.	Depth. Ft.	Cost. cts.
300	27	8	11	20	50
400	27	8	8.5	20	43
500	27	8	7	20	38

The above prices on machine work include \$35.00 per day rental of machine and a yardage royalty of 10 cts. per cu. yd.

NOTE: The cost is figured per lineal foot and not on a yardage basis.

The following cost on a tile drainage trench at Nauvoo Ill. gives another comparison between hand and machine labor. A 15" v 5 1/2' Buckeye Machine was used.

The machine averaged 1600 ft. per 10-hr day in 3 ft. work.

Labor running machine and laying tile.	\$ 12.00
15 per cent depreciation, interest, etc., on \$1700.00 machine,	<u>1.70</u>
	\$ 15.70

In the same kind of soil it took 8 men (expert ditchers) at \$3.25 per day to dig 1600 ft. of 3 ft. trench and lay the tile. This gives a total cost of \$26.00. This shows a difference of \$10.30 in favor of the machine.

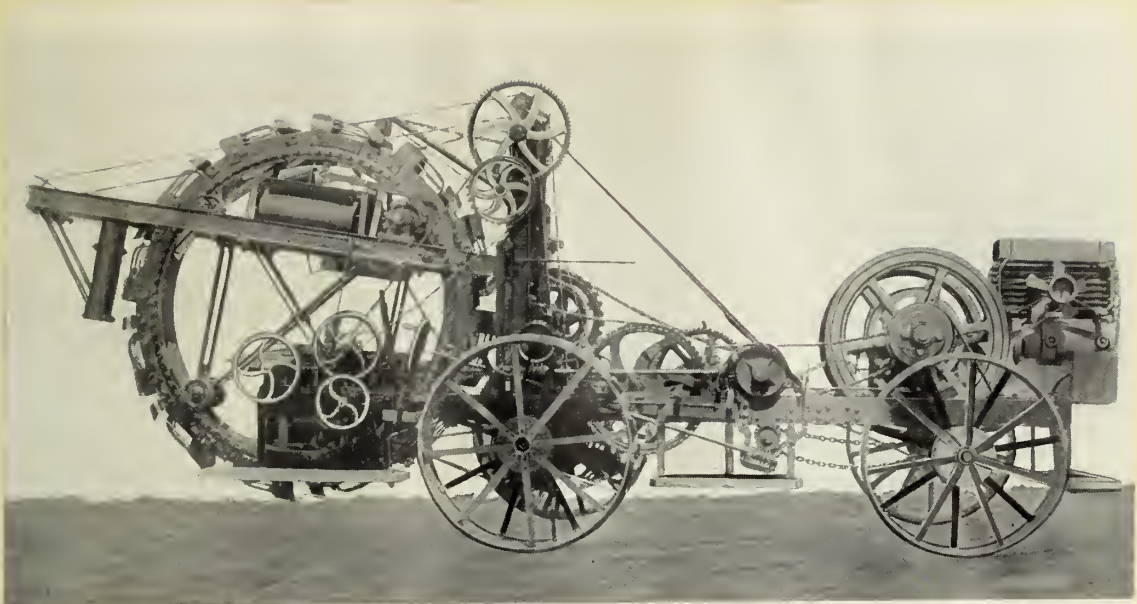
The following are some of the sizes and costs of trenching machines:

DRAINAGE.

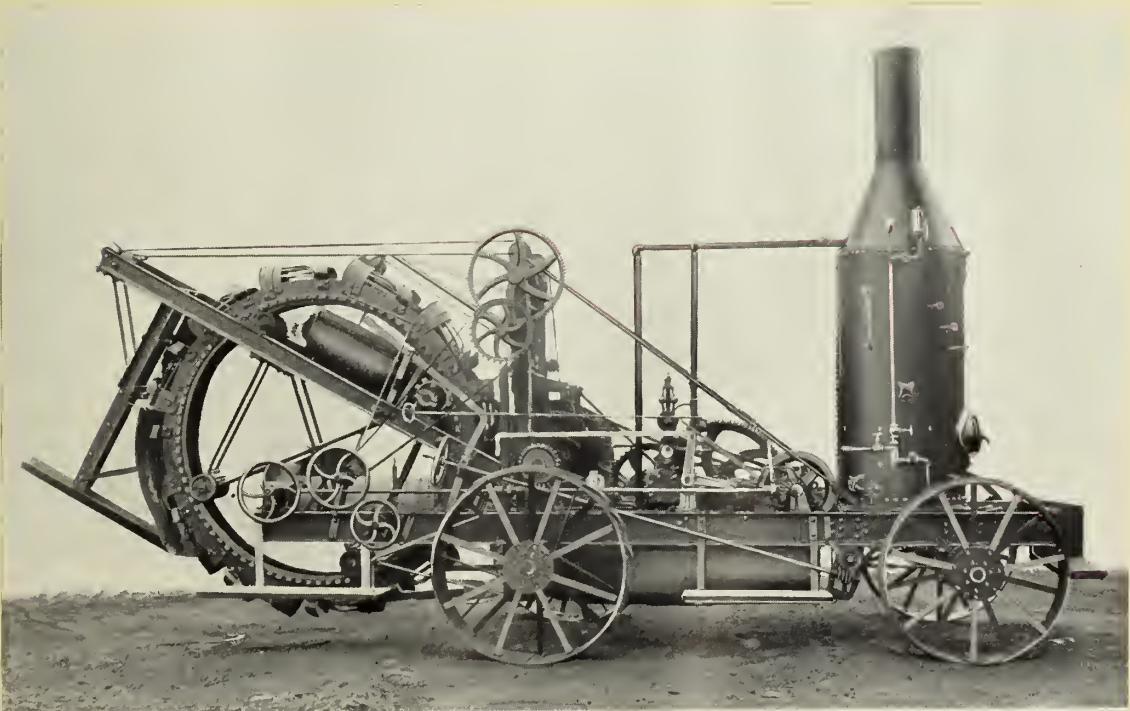
11 1/2 in. x 4 1/2 ft.....	1200.00
With Apron Traction and Ex. Power....	1400.00
14 1/2 in. x 4 1/2 ft.....	1400.00
With Apron Traction and Ex. Power.....	1700.00
15 in. x 5 1/2 ft.....	1700.00
With Apron Traction and Ex. Power....	2050.00
20 in. x 5 1/2 ft.....	3000.00
With Apron Traction and Ex. Power....	3400.00
20 in. x 7 1/2 ft.....	3800.00
With Apron Traction.....	4200.00
24 in. x 7 1/2 ft.....	4800.00
With Apron Traction.....	5200.00

CONTRACTORS.

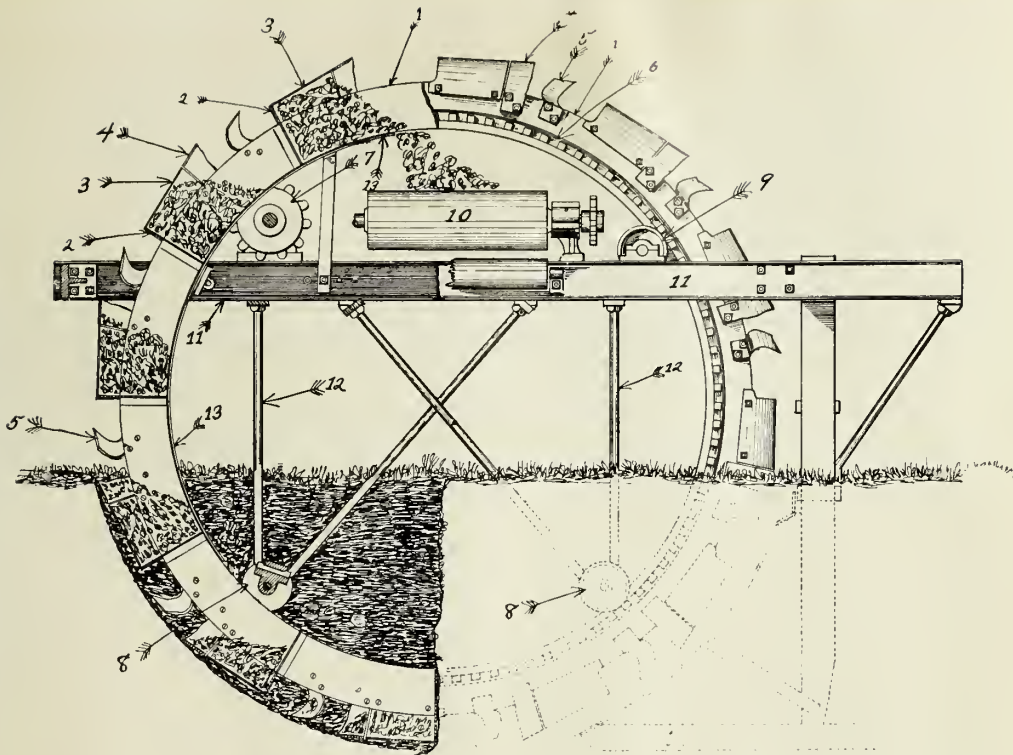
15 in. x 5 1/2 ft.....	2500.00
Same with Apron Traction....	2700.00
20 in. x 5 1/2 ft.....	3800.00
20 in. x 7 1/2 ft.....	4500.00
24 in. x 7 1/2 ft.....	5250.00
24 in. x 10 ft.....	6000.00
Same with Apron Traction....	6500.00
28 in. x 7 1/2 ft.....	6500.00
28 in. x 10 ft.....	7200.00
28 in. x 12 ft.....	8000.00
Same with Apron Traction....	8600.00
32 in. x 7 1/2 ft.....	7500.00
32 in. x 8 1/2 ft.....	7750.00
32 in. x 10 ft.....	7800.00
32 in. x 12 ft.....	8300.00
Same with Apron Traction....	8800.00
36 in. x 7 1/2 ft.....	7800.00
36 in. x 10 ft.....	8300.00
36 in. x 12 ft.....	8600.00
42 in. x 7 1/2 ft.....	8300.00



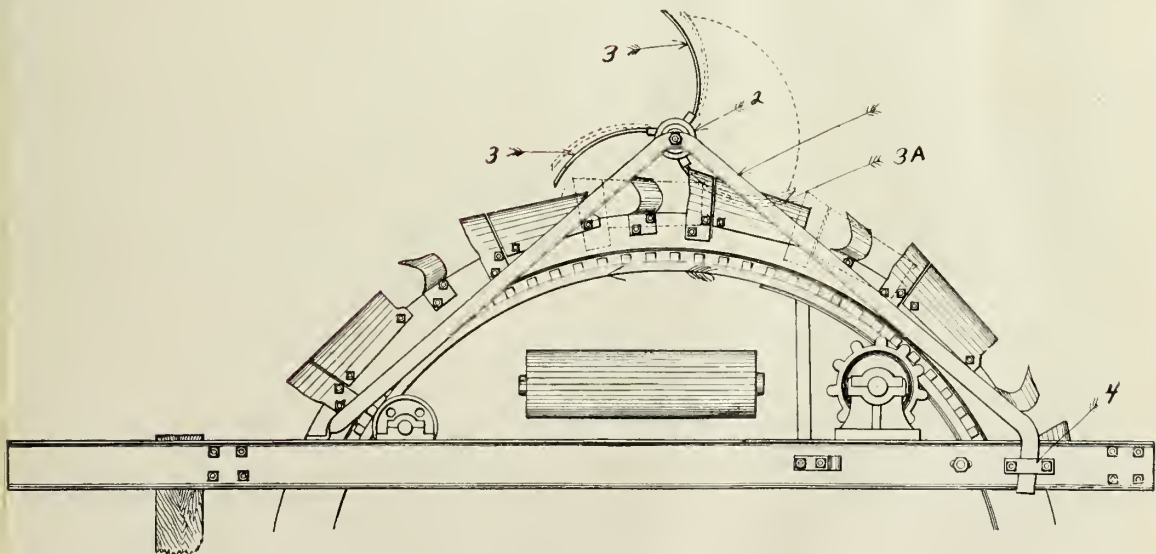
14½-inch x 4½-foot Drainage Machine, equipped with Gasoline Engine.



14½-inch x 4½-foot Machine for Farm Drainage work equipped with Skeleton Buckets for use in wet, sticky soil. Cut shows operator's side of machine, showing Engine, Grading and Guiding Arrangements.



Showing the working of the Excavating Wheel in detail.



DETAIL OF UPPER CLEANER

The arrow represents the inverted V-shaped bars which hold the cleaner in place. They are bolted at the rear of the frame and held in a clamping device at 4, making them adjustable for height. The cleaner head will be noted at 2. Figure 3 represents the spades, and Figure 3A represents in dotted section a spade in a bucket just before it discharges the earth on to the carrier.



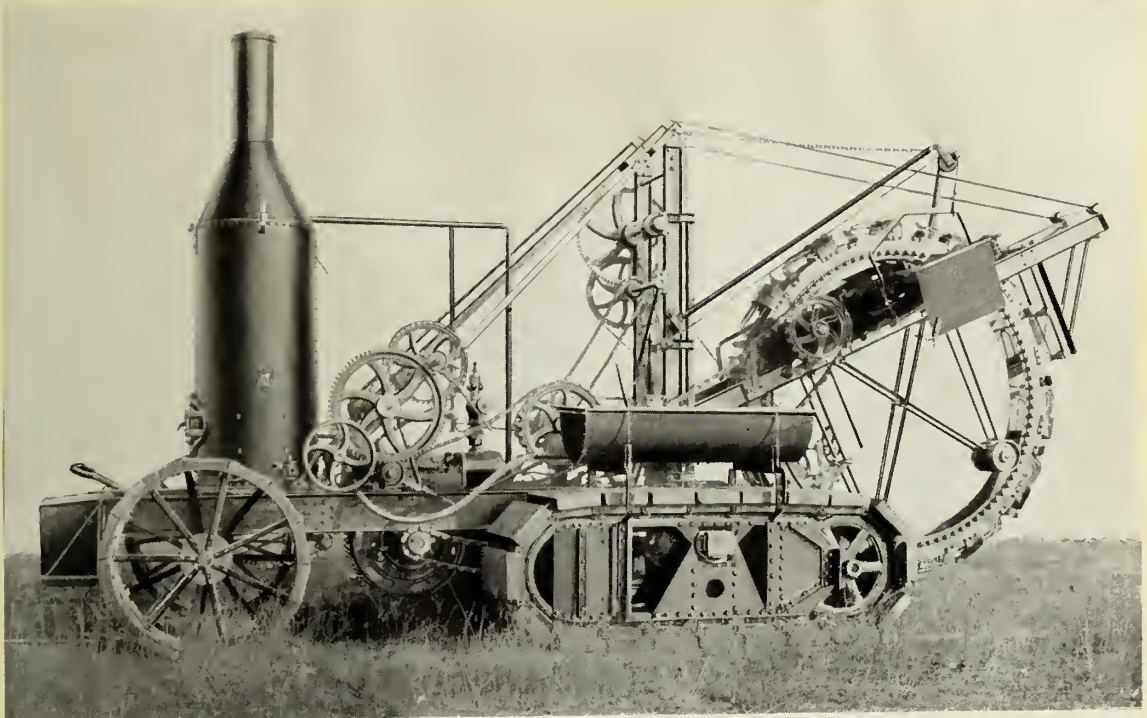
PARSONS TRENCH EXCAVATOR

Owned by E. Lindstrom, Billings, Montana, Excavating Trench in Narrow Alley, Depositing Material on Both Sides of Trench.

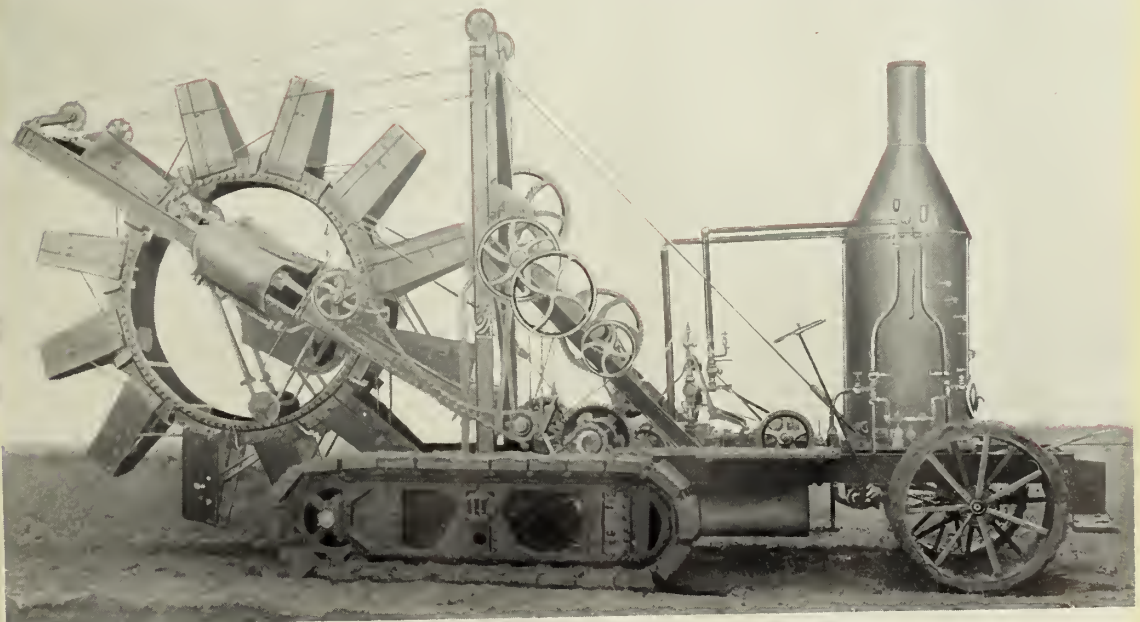


PARSONS TRENCH EXCAVATOR AT WINNIPEG, MANITOBA, CANADA

Dobson & Jackson, Contractors, Winnipeg, Man.



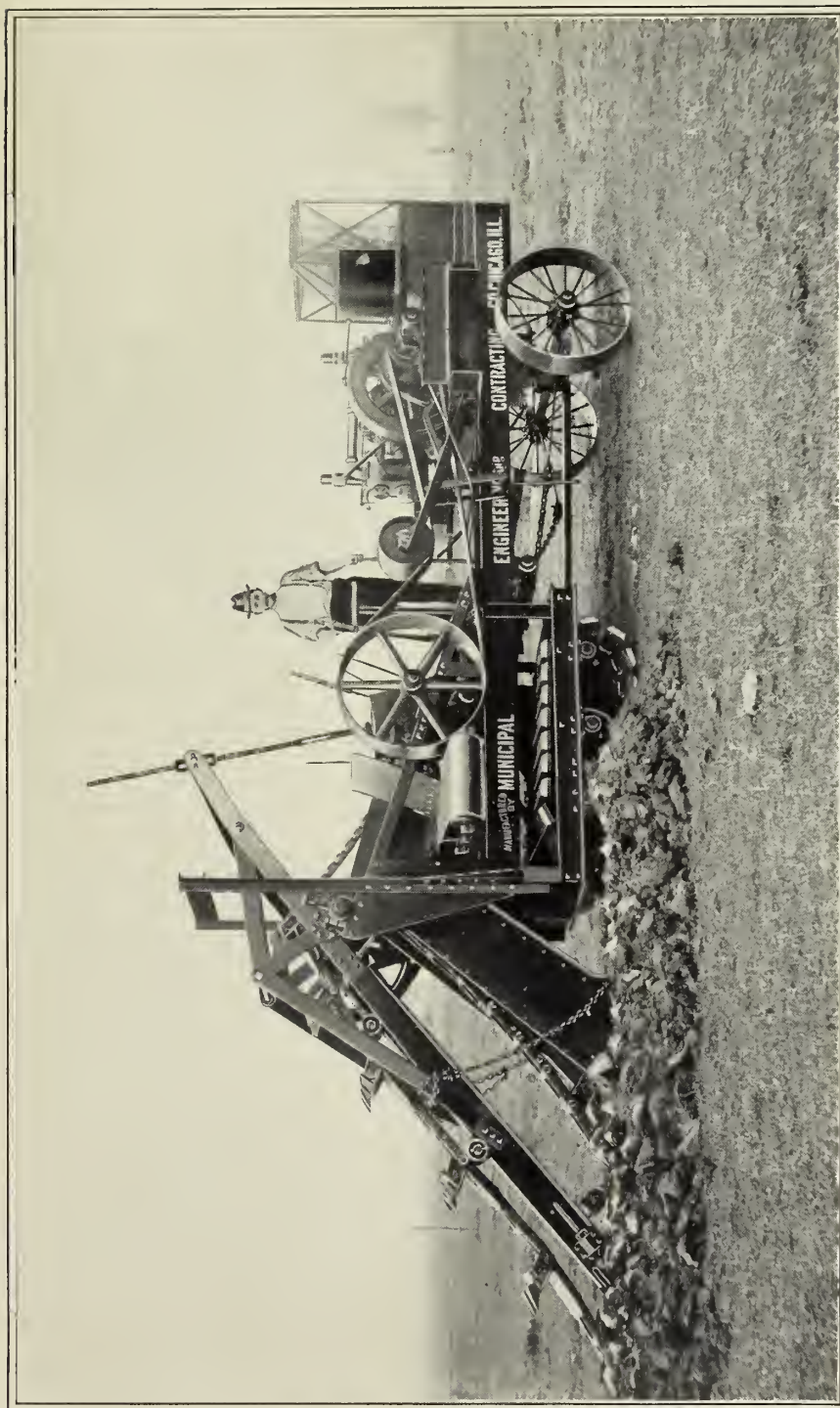
15-inch x 5½-foot Drainage Machine, equipped with Apron Traction mechanism for use in soft soil where locomotion is impossible with an ordinary wagon-wheel equipment,



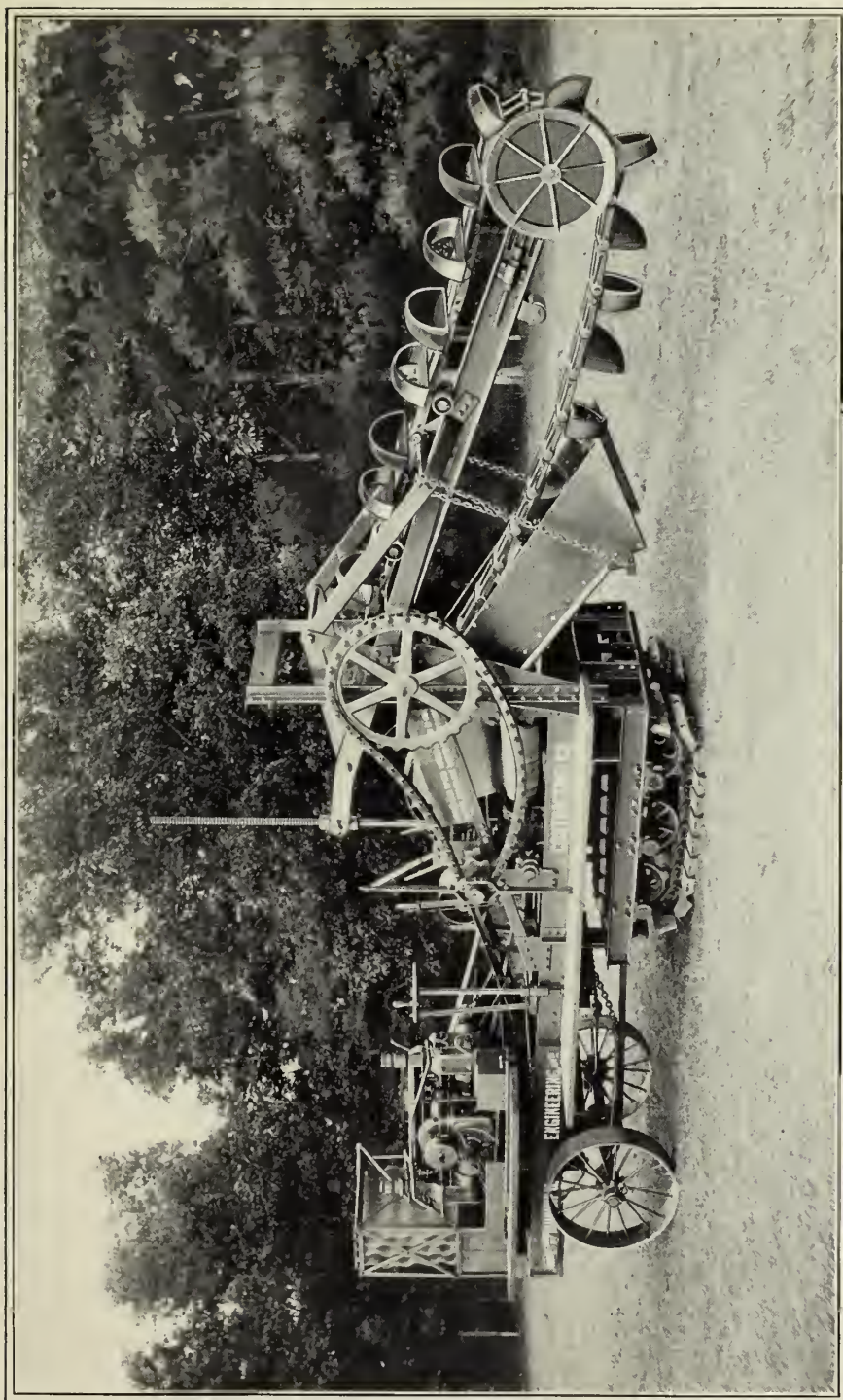
2½-foot x 3-foot Machine for cutting open ditches with sloping banks



View of No. 3 Machine digging trench 20 ft. deep, 32 in. wide.



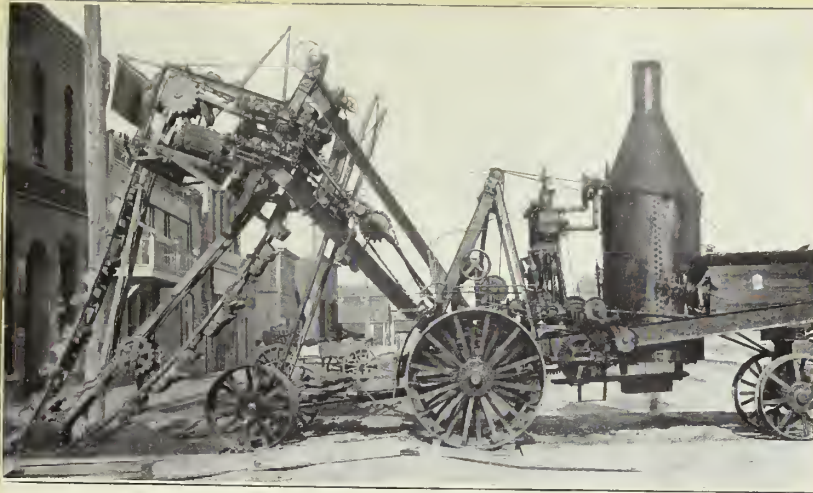
RIGHT-HAND SIDE OF MACHINE SHOWING DISCHARGE APRON.



CHICAGO TILE DITCHING MACHINE ON THE ROAD.



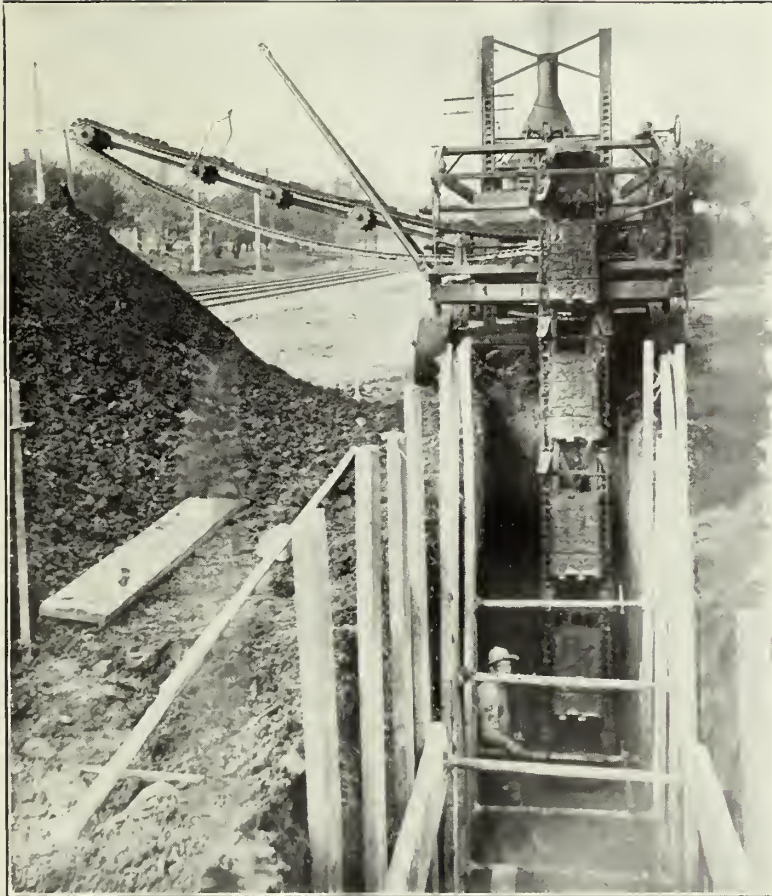
PARSONS TRENCH EXCAVATOR
SHOWING TWO WIDTHS OF TRENCH CUT WITH THE
ONE SET OF BUCKETS



PARSONS TRENCH EXCAVATOR
SHOWING DIGGER RAISED TO PASS OVER SERVICE
PIPES, CROSSINGS, ETC.



PARSONS TRENCH EXCAVATOR
Owned by Julius Keller Construction Co., Indianapolis, Ind.



PARSONS TRENCH EXCAVATOR
EXCAVATING TRENCH FOR SEWERS SEVENTY-EIGHT INCHES WIDE
AND TWENTY FEET DEEP AT DES MOINES, IOWA,
OCTOBER, 1907

J. W. Turner Imp. Co., Contractors, Des Moines, Iowa.

SEWER TRENCH MACHINES. - There are three machines used on large sewer trenches, which excavate the material and also make the back fill. A handy arrangement is that of two derricks with booms about 40 feet long, both placed on the same side of the trench and about 75 feet apart. Both boom and main-falls wind upon drums driven by steam power. With this arrangement a bucket of earth can be hoisted from the excavation, and, passing from one derrick to another, be deposited in the trench 125 or 150 feet away. This plan is not adapted to narrow trenches nor to those where any considerable length is to be under excavation at one time.

For these one of the trestle-machines of cable-ways is preferable, the former more particularly for trenches up to 12 or 15 feet in width, the latter for wider ones and particular cases, such as crossings of railroad tracks.

The cable-way consists essentially of a wire cable suspended over the center of the trench, on which run one or more travellers carrying buckets; the earth being excavated at one point and cast into the buckets, which are raised and carried to the other end of the cable, where they dump the earth upon the completed sewer. It is essential to the safety of the laborers that the cable be substantially anchored at the ends, and that it be amply strong to carry any load which can possibly come upon it. A good plan for the anchorage is to bury a stout platform of timber, inclined backward about 45° from the vertical, to which the cable is fastened. The hoisting and conveying ropes are driven by an engine located at one end of the cable. Like derricks, the cable-way is not adapted

to trenches which move forward rapidly, as the moving and resetting of it takes considerable time and labor.

In the trestle machine the buckets travel upon an overhead track which is supported at intervals by trestles spanning the trench. Generally from 6 to 20 buckets are in use at once, one half of which are being filled while the remainder are being carried to the dump and emptied. In some machines the track forms a long loop, one side of which is for going and the other for returning the buckets. There are then three sets of buckets, one going to the dump, one returning, and one set being filled. To obtain the greatest efficiency of the machine the number of men casting into each bucket should be just sufficient to fill it during the time occupied in removing, emptying, and returning a set of buckets.

The preceeding machinery is economical when the cost of running (including all labor but that of the men digging the trench) and of repairs, plus the rental or interest on the first cost of the machine, is less than the cost of "staging" the dirt out, plus that of back filling.

The cost of these machines is quite small when compared to steam shovels or excavators and depends chiefly upon the price of lumber as the machines are made chiefly of wood.



PLATE XII.—TRESTLE EXCAVATING-MACHINE AT WORK.

DRAINAGE EXCAVATOR.

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This is a special machine designed for work on drainage ditches. It is a self-propelling all steel bridge like structure which supports a runway, or guide through which a wheeled bucket or buckets are drawn transversely across the excavation removing the material in thin layers or slices down one side, across the bottom and up the opposite bank on and out the runway to the desired distance where the bucket is dumped by any one of four different methods used, according to the requirements of the case. After each trip of the bucket the movable runway or templet is lowered a few inches - just enough so that the bucket will fill itself on the return trip and dump on the opposite bank as before.

A drainage excavator, when equipped with the rolling platform traction is operated by two men, namely, an engineer and a fireman for each working shift. With this machine it is customary to run two or three shifts every 24 hours, thus securing continuous operation of the machine. The simplicity of the working parts of the excavator reduces lost time for repairs to a minimum.

The power for operating the excavator is supplied by a 30 or 40 horse power boiler which furnishes steam for a double cylinder double drum hoisting engine.

The boiler will require about 1 1/4 tons of coal and 2400 gals. of water per 10-hr. day.

The first cost of the machine is considerably higher per ton than the cost of a steam shovel or drag line excavator.

The cost is approximately \$160.00 per ton.

Type "A" shown in the following cuts weighs approximately 50 tons and sells at a net price of \$8,500.00

The cost of moving average earth is given by the following data:

	Per 10-hr day.
1 engineer,.....	\$ 3.50
1 fireman,.....	2.25
1 man and team, hauling,.....	
water and coal.....	4.00
15 per cent depreciation, interest, etc., on a \$10,000.00 plant,.....	<u>10.00</u>
Total,.....	\$19.75

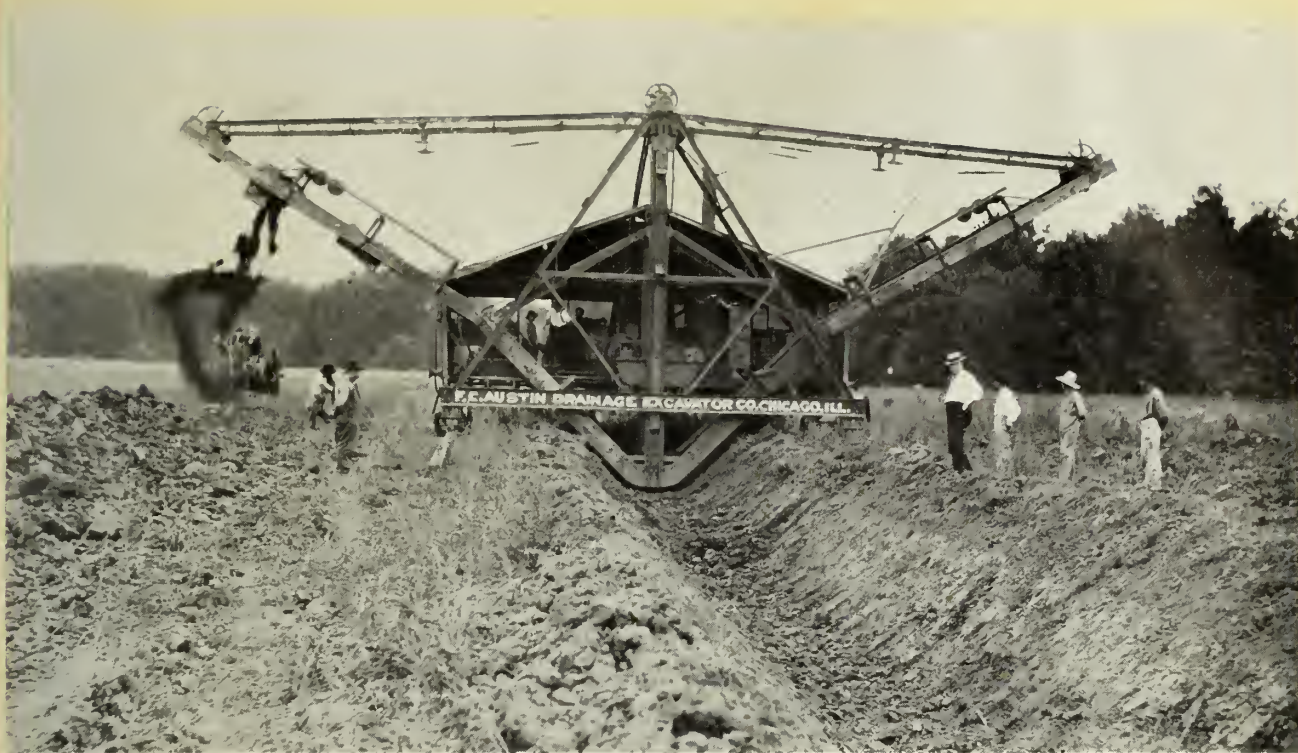
Assuming the machine to be actually operating .7 of the 10-hr. day and moving 2 cu. yds. per minute while in operation, the cost of moving earth is about 2 1/2 cts. per cu. yd.



The Austin Drainage Excavator "Type A" equipped with rear dumping bucket.



Austin Excavator ditch with 4' bottom, $1\frac{1}{2}$ to 1 slope. Depth, 12'. Modified Type A in distance.



Type B Austin Excavator



Rear view of the Austin Drainage Excavator in operation, showing the perfect slope of banks, the continuous waste bank and width of berm.



Surface Cut. Type C Excavator, Los Angeles, Cal.



Type C Austin Excavator. Final cut on Los Angeles Aqueduct. Conduit ready for concrete without hand finishing

EARTH HANDLING MACHINES ON NEW YORK BARGE CANAL.

Contract 40, on the New York Barge Canal, extends from the Lockport Gates westward about five miles to the Sulphur Springs guard lock. In variety of excavating equipment the contract is not surpassed by any used on the Barge Canal. The most important feature is the scheme of combining an excavating machine with each conveying outfit. None of the types of machines employed are absolutely new, and, in fact all of them, though in a somewhat modified form, were used on the Chicago Drainage Canal. The distinguishing feature, however, is the use with each cableway, with the cantilever crane, and with the double boom revolving excavator, of a steam shovel which loads the skips removed by the conveying outfits.

The excavation work on this contract consists in deepening and widening the present Erie canal, and in constructing a wide harbor section in Lockport. About one-third of the length of the contract, at the western end, is an earth section, and the remainder is rock or rock and earth. The estimated quantities are 850,000 cu. yd. of rock, and 1,4000,000 cu. yd. of earth, the latter including the stripping over the rock. This classification has a bearing on the type of construction equipment employed, since the earth work section could be excavated in summer while navigation was in progress, while, on the other hand, rock work must be confined solely to the winter months, between November 15 and May 15, when navigation is closed. In the one case a large cantilever crane has been employed, which can operate either in the navigable or in the closed season, while the

other steam shovels are placed in the prism of the canal and transfer spoil to a variety of hoisting and conveying equipment to the banks above.

The Lambert cableways are of 10-ton capacity, designed to operate a 5-yd. skip. Each has a span, variable between 400 and 500 ft., an 85-ft. head tower and a 60-ft. tail tower. This span allows the tail tower to be set back far enough on the north bank to clear the roadway along the canal and on the south bank to clear the spoil area. Both cableways are operated by compressed air from the central station and a 4-in. line is carried across the canal for this purpose. Connections are placed at such intervals that 40-ft. of 4-in. air hose are sufficient between the permanent piping and the head tower. The Marion shovels, a Model 20 at the west end and a Model 75 near the mid-point of the contract, which load the cableway skips, are also driven by compressed air. Two skips are used on each cableway, one being in transit while the other one is being loaded.

For taking out the earth section the contractors, in May, 1909. installed a large cantilever crane, manufactured by the Brown Hoisting Machinery Company of Cleveland, Ohio. The machine is $282 \frac{1}{3}$ ft. long over all and is mounted on a tower with a 35 x 37-ft. base. The cantilever arm overhanging the canal is 192 ft. 9 in. long and that over the spoil bank 152 ft. 1 in. The bottom chord of the crane stands at an inclination of $2 \frac{1}{4}$ in 12 and the trolley has a run of 360 ft. measured on the horizontal.

The sketch on page 176 shows the construction of the crane.

This machine was designed to operate a Brownhoist automatic dumping shovel bucket and was placed on the berm side where it offered no interference with canal traffic. The longer arm, however, extended across the canal and over the tow path on the opposite bank. It was possible to use this outfit while navigation was in progress and it was so employed throughout last summer and fall. The material in the bed of the canal is a clay silt which has been compacted by the overburden so that it has become stiff, and of a rubbery consistency. When this was encountered the capacity of the crane was considerably cut down, and in the fall, the use of the crane was temporarily suspended, until a number of 180 cu. ft. Brownhoist spoil tubs were obtained.

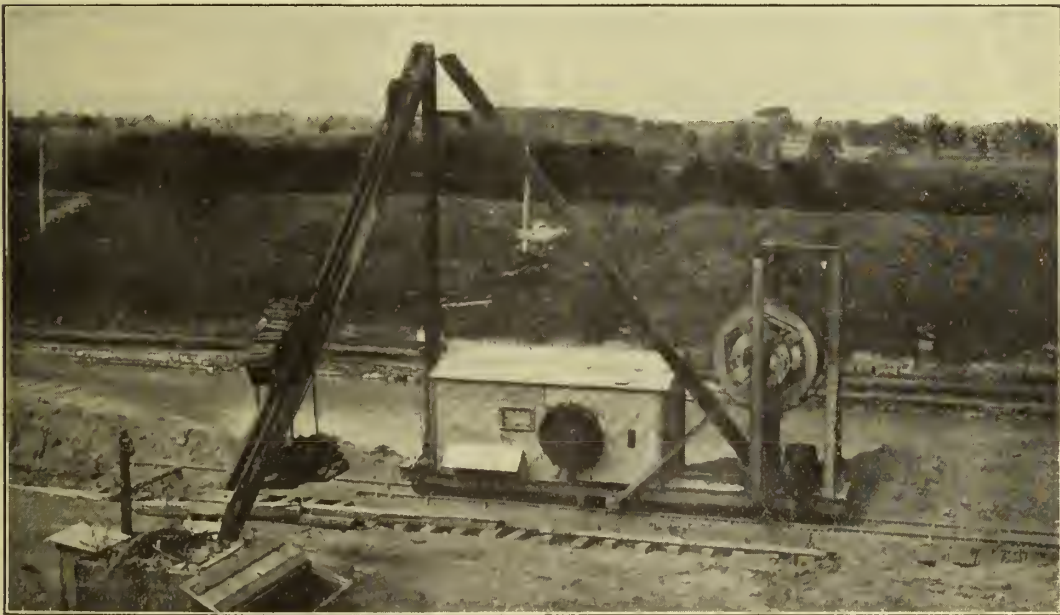
Since the early part of December, the crane has been used solely as a conveyor, the tubs being loaded by a Model 75 Marion steam shovel.

In beginning the earth excavation, a Brownhoist single-line grab bucket of 2 1/2 cu. yd. capacity was used on the crane in order to dig a ditch parallel with the axis of the canal into which the drag bucket of the cantilever was dropped to get a start on the work.

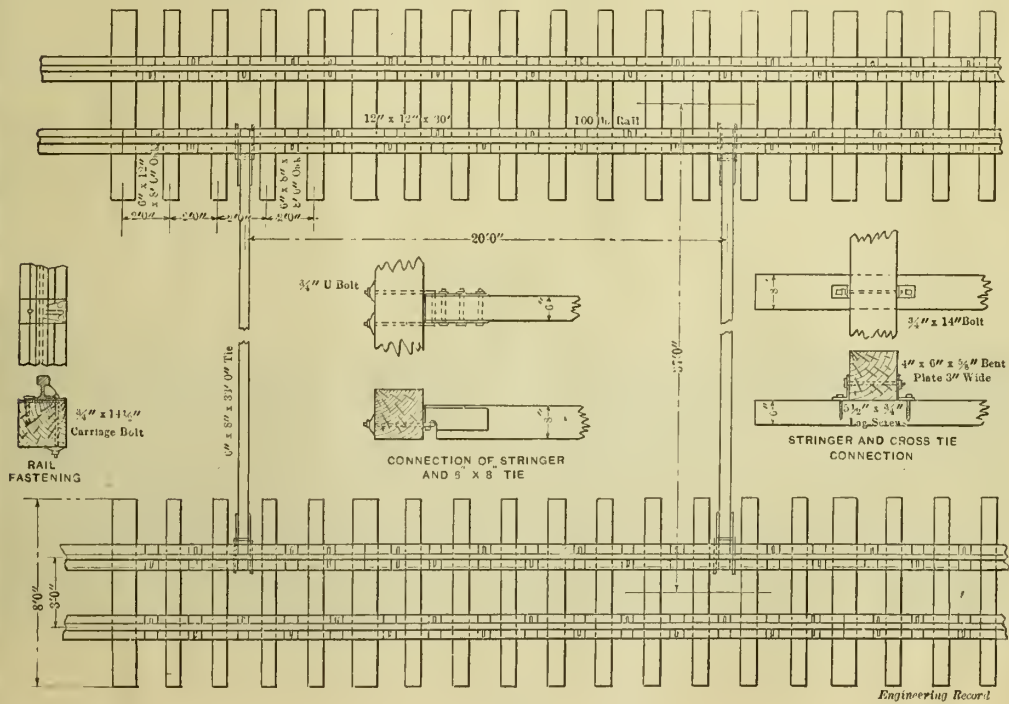
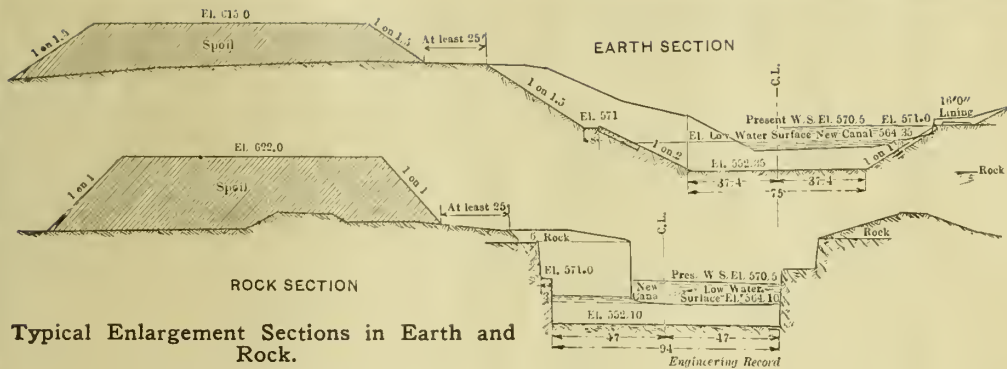
The crane is operated by a 225 hp, 25-cycle General Electric induction motor, wound for 480 r.p.m. under a pressure of 440 volts. This is geared to two drums, one for the hoisting and one for the trolley traverse ropes. A set of beveled gears on the main shaft are used for moving the crane along the canal. The operations are controlled by means of clutch levers attached to the ceiling of the operator's cabin. The brake bands are operated by foot levers. A 5/8 in. cable is used for

hoisting and traversing the trolley, and an additional cable is used as a tail line to steady the trolley. The machine is operated in three eight-hour shifts per day. The work is lighted at night by flaming arcs over the canal, and incandescent lights are placed on all parts of the machine.

Power for the cantilever is obtained from the three-phase transmission line on the north bank. Connections are made to this line by three wires suspended across the canal, terminating on the berm side in a traveling transformer car.



Transformer Car for Allowing Independent Travel of Cantilever Crane.



Track for Cantilever Crane.

The crane travels on four 4-wheel trucks, one beneath each leg of the tower. In some cases it has been necessary to do considerable cribbing where hollows had to be crossed. The track construction used where the ground is level and at the average elevation is shown in one of the drawings. This scheme insures a track with all rails properly spaced, and safeguards against the rails spreading. The rails rest on tie-plates and are provided with rail braces, while the stringers are properly spaced and held by short lengths of angles spiked to the ties.

About 240 ft. of such track is used, and depending somewhat on the progress of the work, either one or two 30-ft. sections are moved ahead in a day, requiring the services of eight men, and the use of a single-drum air-driven hoisting engine, which drags the parts of the track ahead.

Each operating shift consists of three persons, an operator, an oiler, and a tally boy. In addition an extra handy man is generally employed on the day shift, acting as a relief for the operator and looking after simple repairs which do not necessitate the shutting down of the machine. Each crew, as a general rule, is able to take care of any small breakdowns so that it is kept employed even when the crane is out of commission. There is thus no great loss when the cantilever is tied up.

When working uninterruptedly for eight hours as high as 1000 cu. yd. have been made, and the maximum yardage for any one month, in October, was 42,080. As a general average a round trip of the bucket was made in about 1 1/2 min. though in individual cases trips have been made in half that time, 45 sec.

One feature of the operation of the crane that is advan-

tageous. is its use as a conveyor to carry the spoil lengthwise of the canal. The traversing speed is 125 ft. per minute. In one case it was necessary to leave an opening in the spoil bank for a highway, and the earth taken from the prism opposite this opening had to be deposited either to the east or the west of this point. This was accomplished by excavating in the usual manner but instead of discharging the bucket immediately the cantilever was moved parallel with the canal until clear of the highway opening when the trolley carrying the bucket was continued on its way and dumped.

DOUBLE BOOM EXCAVATOR. - The double boom excavator near the eastern end of the contract was placed in service in December, 1909. This machine is operated with a 5-yd. skip on each boom and has the skip bails so arranged that it is not necessary to unhook the skips in order to load them.

The machine weighs about 150 tons and has two 100-ft. booms, which when elevated at an angle of about $28\frac{1}{2}$ deg. to the horizontal have their tip ends at a horizontal distance of about 100 ft. from the center of the machine so that the reach is 200 ft. It is designed to lift and carry a load of 10 tons, including the weight of the skip, on each boom simultaneously, or to operate a $3\frac{1}{2}$ yd. drag scraper bucket on one boom. The machine is mounted on skids and rollers and is moved along by throwing the drag bucket forward, getting a firm bite, and pulling on the drag line, or by attaching a lead line to a deadman and passing it over a niggerhead to one of the main engines. The machine was designed to make 30 complete revolutions in an hour, which would mean the loading and discharging of one 5 yd. skip every minute.

In practice, due to the natural limitations of steam shovel work, this rate cannot be attained, as the shovel cannot equal the capacity of the excavator. The best record thus far has been 151 half revolutions or 151 skip loads in six hours. The attained rate, however, is understood to be satisfactory on the basis of operating cost, interest on first cost, and maintenance. The machine is being used in a section where the entire excavation is in rock.

Three men are required for the operation of the machine, one to control each of the boom engines, and the third to run the rotating engine. Five other men are required to advance the track for the machine and one man is placed in the canal prism to signal the operators. Beyond this signal man no other attendants are required in the prism so far as the double boom excavator is concerned, the skips requiring no attention whatever.

The machine is operated by compressed air received from the central plant and has a pressure of 80 lb. to the square inch at the machine.

The stationary bed or truck on which the excavator is carried is built of special 24 in. x 72-lb. Bethlehem I-beams for both the side and diagonal members. The frame is about 25 ft. square, and is carried upon oak runners and skids and maple rollers.

On top of this lower frame is a circular 90-lb. rail, inside of which and bolted to the main frame is the steel ring gear which meshes with the rotating spur pinion on the revolving deck. The track is 24 ft. in diameter.

The rotating structure consists of a framework of steel

beams, channels, and angles rivited together, and the deck supports the machinery directly on its main members. A truss 9 ft. deep is placed on each side to distribute the loads from the booms and mast to the roller supports of the rotating frame. From the top of the trusses a mast extends to a height of about 24 ft. At the top is a horizontal steel shaft supporting the boom sheaves. Back stay rods connect the top of the mast to the rear top corners of the side trusses and sway-bracing is provided where necessary.

The boom has a width of 1 ft. 3 in. at the tip, 16 ft. at the base, where it is hinged to the machine, and a maximum depth, at the center, of 4 1/2 ft. Over its top is a plank walk 24 in. wide.

The rotating engine is placed on one side of the crane and the levers are in such a position that the operator can observe both booms. The engine is an 8 x 8-in. double cylinder machine. The two 12 x 12-in. double cylinder main engines are each placed directly at the base of the booms so that the operator has full view of all movements. Each engine has three separate drums, two mounted upon one of the shafts, but arranged for independent operation. There is one drum each for the hoist, dump and drag lines.

The 5-yd. skips used on the machine are 8 ft. square and 2 ft. 3 in. deep on the inside. They are made with 3/8 in. plates and are provided on the bottom with three longitudinal skids consisting of 6 x 6-in. x 8-ft. white oak timbers. These are bolted to projecting angles, and to the bottom plate of the skip.

Each skip is carried by two bails, the vertical parts of which are 7 ft. long. These members are made of 1 x 6-in. bars and have across the tops a separator consisting of two 9-in. 13 1/4 lb. channels. These horizontal separators, in turn, have a third separator, also placed horizontally, but at right angles to the first pairs. The hooks below the tackle blocks are attached to rings in the top of the first separators, and by taking up on one line more than on another the particular bail to which the higher block is attached takes a vertical position, thus throwing the center of gravity of the whole system beyond the vertical and dropping the bail to one side. The bail falls clear of the skip pan so that it can be loaded by the steam shovel. This scheme avoids unhooking.



Double Boom Excavator and Steam Shovel in Canal for Serving It.

CONCLUSION.

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Each earth moving machine is especially adapted to certain kinds of excavation.

The hand-shovel, besides being used in connection with nearly all other excavating machines, when its use is necessary for the final dressing of the surface of the excavation, is especially applicable where the quantity of earth to be moved is too small to permit the economical operation of a larger machine. For small jobs its use is general. The chief objection is the high cost of operation coupled with the slow rate of moving any quantity of earth.

Wheel-barrows are economical only where the space is too confined to permit the use of teams. Over-haul is usually paid on all distances over 50 feet. This indicates that the expense of wheel-barrow work on hauls over 150 feet is prohibitory.

One-horse carts are advantageously used in making embankments on work of moderate extent and where the job is too small to permit the installation of track and dump cars. In dumping off of the end of a fill, carts are superior to rear end dump wagons owing to the greater ease of backing the load up to the end of the embankment. They are especially well adapted where the space is too confined for the operation of dump wagons, and on hauls too great to permit the economical use of wheel-barrows.

Patent dump wagons are necessary for the successful operation of the elevating grader when the material is to be removed from the excavation site. For making broad, though not necessarily deep fills, on hauls of from 800 to 3000 ft., the patent dump wagon cannot be excelled when operating in connection with steam shovels, excavators or traps.

Drag scrapers can be operated economically on hauls under 250 or 300 feet. Even on small jobs, if there is sufficient space in which to manoeuver the teams, drag scrapers can compete successfully with wheel-barrows even on hauls as short as 25 feet.

Wheel-scrapers are well adapted for hauling earth any distance between 200 and 800 feet, approximately. Even though they require greater space for operation than the drag scraper, they are more economical for hauls of 200 to 300 feet. On short hauls the cost of operating the wheel-scraper is greater than that of the drag scraper, due to the fact that a man and "snatch" team is required for loading the wheel scraper, but on account of the larger capacity of the wheel scraper the cost does not increase as rapidly with increased length of haul. On hauls of about 200 feet, the cost of moving earth is about equal with both kinds of scrapers.

Fresno scraper is excellent for moving light or sandy earth any distance up to 500 feet. On uphill hauls it operates with about the same economy as a drag scraper. One or two extra horses are required with the fresno scraper but its greater capacity offsets this added expense. On down grade hauls, in light or sandy soil, it is a very economical dirt mover, as a

large amount of earth is pushed along ahead of the bowl. In heavy material which has not been thoroughly loosened the fresno scraper is so hard to fill that it is not economical.

In excavating shallow drainage ditches, from 2 to 8 feet deep, and on road and street grading, where there is prairie soil free from roots, stumps, and boulders, the elevating grader is the most economical machine on the market. Elevating graders, used in connection with dump wagons on road work and in stripping reservoir sites operate more successfully and at a lower cost than other machines suitable for this purpose. Elevating graders are not economical unless operated on long stretches where turns are infrequent.

Dump cars of all descriptions are very economical when the material is dumped through a trestle. In case the ground over which the material is hauled is soft, dump cars are much more efficient than carts or dump wagons. The roadway is cut up by only one horse instead of by a team and wagon or by a horse and cart. One horse can haul a greater load in a car than in a dump cart. The size of excavation and length of haul determines in nearly all cases whether a "dinkey" shall be used. Hauling trains of dump cars with a dinkey is the most economical way of moving earth with cars.

Steam shovels can be operated economically only on work of considerable size where moves are infrequent. They are especially adapted for digging clay in brickyards, mining cement rock in cement quarries, and in making railroad cuts in which the material is used for fills and in other places where the excavated material has value. These machines can excavate

harder and tougher material than any other earth moving machines on the market.

Excavators are more frequently operated on work in which the excavated material is thrown out on a spoil bank. Owing to the excavating bucket not being held rigidly in the earth as in the case of the steam shovel, excavators are unable to operate under such adverse circumstances as the steam shovel can. One advantage the excavator has over the steam shovel is that it operates either from the floor of the cut or from the top of the bank and does not have to be moved so often. Another is that it can deposit the excavated material in a spoil bank at a much greater distance from the cut. The disadvantage of both of these machines is the difficulty of moving from place to place, but when once they are on the work they can excavate material at a very low cost when compared with other methods.

Trenching machines, on work of considerable size, are very economical because one machine takes the place of from 50 to 100 men, depending on the depth of the trench and the kind of soil. It should be used in place of hand labor where the tile or sewer is required to be kept up close to the face of the cut, as on busy streets of a city, and also where it is necessary to eliminate the danger of caving.

The machines used on the New York Barge Canal are very ingenious and give methods by which the excavations can be made at a rapid rate and a reasonable cost.

Without the large and powerful excavating machines work of great size, such as heavy railroad work, the New York Barge Canal, and the Panama Canal, would be almost impossible as well as

impracticable to perform.

The problem of choosing machines and planning their methods of operation on earth excavation is one of the greatest factors in determining the time and cost required to perform the work. The kind, amount and situation of the excavation, the nature of the soil and the length of haul, are the prime factors in determining the kinds of machines to be used for successful and economical performance.





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